US Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources

GUIDEBOOK FOR RISK PERCEPTION AND COMMUNICATION IN WATER RESOURCES PLANNING

Part I

- Underpinnings and Planning Applications -

October 1993

IWR Report 93-R-13

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, WATER RESOURCES SUPPORT CENTER
INSTITUTE FOR WATER RESOURCES
7701 TELEGRAPH ROAD
ALEXANDRIA, VA 22315-3868

REPLY TO ATTENTION OF

June 24, 1994

CEWRC-IWR

MEMORANDUM FOR COMMANDER, Defense Technical Information Center, Cameron Station, Alexandria, VA 22314

SUBJECT: Transmittal of IWR Report 93-R-13

1. Reference AR 70-31.

2. Two copies of IWR Report 93-R-13, "Guidebook for Risk Perception and Communication in Water Resources Planning: Part I - Underpinnings and Planning Applications", has hereby been submitted

3. Initial distribution of this report has been made to appropriate Corps of Engineers agencies. It is recommended that copies of this report be forwarded to the National Technical Information Center.

4. Request for the DTIC Form 50 (Incl 2) be completed and returned to WRSC-IWR.

FOR THE DIRECTOR:

Enclosure

Kyle E. Schilling
Director

Guidebook for Risk Perception and Communication in Water Resources Planning

Part I – Underpinnings and Planning Applications

A Report Submitted to the

U.S. Army Corps of Engineers
Institute for Water Resources
Casey Building
Fort Belvoir, Virginia 22060

by
Clifford Russell

for
Planning and Management Consultants, Ltd.
Rt. 9 Box 15 (Hwy 51S)
P.O. Box 1316
Carbondale, Illinois 62903
(618) 549-2832

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Preface

This report is a product of the U.S. Army Corps of Engineers' *Risk Analysis for Water Resources Investments Research Program* managed by the Institute for Water Resources which is a unit of the Water Resources Support Center. The report was prepared to fulfill part of several work units in the research program. These work units focused on developing and applying the concepts of risk preference and risk communication to water resources issues. The report conforms to the basic planning model and to the risk and uncertainty analysis recommendations presented in "Economic and Environmental Principles and Guidelines for Water Related Land Resources Implementation Studies" (P&G).

The risk analysis framework encompasses the four basic steps in dealing with any risk: characterization, qualification, evaluation, and management. The purpose of conducting these analyses is to provide additional information to both Federal and non-Federal partners on the engineering and economic performance of alternative investments that address water resources problems. The goal is to produce better informed decisions and to foster the development of the idea of rational joint consent by all parties to an investment decision.

The guidebook consists of six chapters, a bibliography, and appendices. The chapters provide an overview of the terminology and concepts of risk, risk perception, and risk communication with the public as applied to water resources. It introduces the planner to a methodology to solving water resources planning problems that explicitly includes both risk and uncertainty and public involvement.

This report was prepared by Planning and Management Consultants, Ltd. under terms of a contract with the U.S. Army Corps of Engineers Institute for Water Resources. Dr. Eugene Z. Stakhiv was the initial contract manager and was succeeded by Dr. David A. Moser of the Technical Analysis and Research Division. The Chief of the Technical Analysis and Research Division is Mr. Michael R. Krouse and the Director of IWR is Mr. Kyle Schilling. Mr. Robert Daniel, Chief Economics and Social Analysis Branch, Planning Division, Mr. Early Eiker, Chief, Hydrology and Hydraulics Branch, Engineering Division, and Mr. James Crews, HQUSACE, served as technical monitors for the research program. Numerous field reviewers provided valuable insights and suggestions to improve early drafts.

Acknowledgements

The guidebook evolved from the contributions of several prominent researchers in risk perception, behavior, and communication. Professor John Sims of Illinois Benedictine College, and Dr. Kurt Alley, private practitioner, prepared papers on the effects of risk communication problems and prospects and on the effects of personality on risk perception and decision making. Professor Ann Fisher of Pennsylvania State University provided her perspective on risk communication based on her experiences with several federal agencies. A discussion of the effects of socio-cultural factors on risk perception and behavior in the face of risk was contributed by Professor Ortwin Renn of Clark University. Additional meaningful criticism and contextual examples of risk communication were provided by Drs. Duane Baumann, John Langowski, Jerzy Kocik, and Kevin O'Grady of Planning and Management Consultants, Ltd.

A special note of deep gratitude is extended to Edward Pettit, Donald Hayes, and Judith McFarlin for their administrative assistance and office support.

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Executive Summary

The purpose of this guidebook is to provide observations and theories about how people perceive risk and to set out guidelines that will assist water resource planners and managers in their efforts to communicate with the public and with decision makers about situations in which risk is important. Elements of risk and uncertainty are found in all areas of water resource planning and management. Different techniques for characterizing risk as well as different methods for identifying desirable strategies for dealing with risk are found in different areas (flood control, navigation, drought, environmental management).

The guidebook consists of six chapters, a bibliography, and appendices. It develops a picture of what is known about the public's perceptions and reactions to risk and the best policies and methods of communication with the public about risk. An extensive bibliography is provided under separate cover for those wishing further information on these topics (Part II - An Annotated Bibliography).

Chapter II discusses models of risk behavior. It establishes the foundation for risk analysis and management and discusses the problems that interfere with straightforward application of this foundation.

Chapter III deals in more detail with the methods people use to filter information pertaining to risk situations. This chapter ties directly to the public's perceptions of, and reactions to, risk, and the role of precognitive, emotional response is emphasized.

Chapter IV discusses what is known about human cognitive operations in uncertain situations.

Chapter V deals with the effects of social pressure on risk perceptions and the potential for social amplification of risk perceptions.

Chapter VI is the heart of this manual. It provides guidelines for risk communication that represent the lessons to be drawn from the problems discussed in the previous chapters. Two situations are distinguished. In the first, public understanding of a program or project is what is at stake. In the second, the Corps decision makers believe that there is a need for public action, especially action in response to some natural hazard. The following pages of this summary will focus on Chapter VI.

Guidelines for Risk Communication

There are four elements of the risk communication process that need to be considered by the planner:

- *Objective(s)*: Why is the communication being undertaken?

- *Content of the message*: What information is to be conveyed in order to accomplish the objectives?

- *Form of communication:* How should the message be transmitted from the source to the receiver?

- *Feedback from the audience*: What is being received?

Two broad alternative objectives are (1) the planner may want to provide the audience with a better understanding of the risk and uncertainty surrounding planning alternatives and thus to stimulate cogent and informed discussion—and ultimately a defensible resolution; or (2) the planner may desire to communicate risk in order to encourage appropriate behavior by individuals and communities. Message content and audience feedback will vary depending on the objective. The form of the communication is less dependent upon the objectives.

When Understanding Is the Objective

The guiding principles, which pertain to the content of the risk information program, can be summarized as follows.

- Uncertainty should be expressed in a variety of ways using such physical analogies as wheels of fortune and jars containing colored balls. Care should be taken to use language and mechanisms that do not encourage thinking of independent events as cyclic, with fixed return intervals. (The common expression, "100-year flood," may be counterproductive.)

- Disagreements among experts should be made explicit and not concealed. If possible, the range of opinions should have probability weights attached to the alternative possibilities.

- The decision problem outcomes should be framed in at least two ways, one stated as losses from best case and one as gains from worst case.

- Stress the analogy of the project to an insurance policy against catastrophic loss whenever this is appropriate.

- Provide information that allows the audience to assess the risk (at least in terms of threats to life and limb) of the contemplated project or program relative to other activities and programs, both individual and collective.

While the principles developed above for the content of risk communication attempt to anticipate and deal with specific problems, success can by no means be guaranteed. Accordingly, it is well to check on the progress (or lack of it) being made. The following is a minimal checklist.

- Check for the audience's interpretation of probabilities in the case at hand. This may involve pretesting physical analogy models for definitional fitness (e.g., the wheel of fortune). Another question is whether the notion of independence is getting across or requires reinforcement. A third general problem area to be explored is the possibility that the audience contains a significant number of people who subscribe to some sort of causal or ethical theory of the events in question that interferes with their ability to think of them as random.

- Check for the presence of patterns of utility weights that would point toward incautious policy prescriptions. Perhaps the largest concern here is the possibility of risk seeking when all options will lead to losses.

- Check for the possibility of internal confusion such as that evidenced by the preference reversal phenomenon. This will

probably involve asking preference questions two ways: one using strictly preference terminology; the other using the willingness-to-pay format developed in the contingent valuation literature.

When the Objective Is Action

With this objective we have somewhat more experience, primarily because the effects of weather-related hazards are often mitigated through voluntary action by citizens; the campaigns that call forth that volunteering have been studied and refined over the years. Examples of events that are conducive to the voluntary actions of citizens include shoring up a levee with sandbags to prevent flooding and a door-to-door campaign to warn people of approaching or impending danger such as a flood, brush fire, or hurricane. The guiding principles which pertain to content can be summarized as follows.

- The campaign should effectively convey a message about the seriousness of the risk. This effort should not, however, be allowed to degenerate into a scare campaign, for the behavior triggered by fear is likely to be counterproductive.

- The program should provide social reinforcement of risk reduction behavior especially at the local level. This will cultivate strong group interest and moral commitments within the community.

- The campaign should make an attempt to convince the consumers that their actions aimed at reducing risk will help to mitigate risk impacts.

- Risk reduction efforts requested by the campaign should be equitable. All members of the community should be required to make sincere efforts to reduce the risk.

- The specific strategies of the campaign should rely, to the extent possible, on providing feedback on risk reduction efforts and providing economic and social incentives for doing so.

With respect to gleaning feedback on the key issues, the following four items are particularly crucial.

- Check to make sure that the actions being touted in the campaign are perceived as effective in mitigating the threat.

- Check that the audience sees the goal of the campaign and the manner of its application and enforcement as fair and effective (e.g., one group, neighborhood, or town is not seen as carrying the load for others).

- Check that the seriousness of the threat has not been so emphasized that significant amounts of regressive behavior have begun to show up.

Note that time constraints may not allow gathering feedback during an event; ex post research may be required.

The Form of Risk Communication

Past research and theories of persuasive communication suggest several important requirements in designing maximally effective messages, whether the objective is to induce understanding or action.

- Messages should be vivid, that is, evoking lifelike images within the mind.

- Messages should come from a credible source. Information from authoritative sources is more likely to be believed and, therefore, acted upon. It may be useful to combine the information from various sources even if they appear at odds over a particular issue (e.g., environmental groups and chemical companies).

- The message should be clear, specific, concise, and concrete. Words used in a message should immediately bring an image to a person's mind. Specific but concise messages are easier to read and understand.

- The message should be clearly applicable to the person receiving it. This requires that information should be "personalized" or "localized."

- The means for delivering the message should make the maximum use of person-to-person communication through local media personalities, leaders, and citizen advisory groups. Impersonal messages should be avoided.

- Modeling of risk reduction behavior by respected individuals in the community should be sought as the most powerful means of persuasion.

Introduction to the Guidebook

Chapter 1

Introduction

The extent to which all human activities proceed in a setting of uncertainty about the future is captured in the old saw: "Nothing is certain but death and taxes." But like all such saws, this one could do with some straightening and sharpening, for while all humans are destined to die, none of us can know the time or manner of our passing. More important, we can never even be sure that efforts we make to affect the certain event are doing the slightest good. And where taxes are concerned, it is impossible to predict year-to-year changes in the key rules that influence how we seek income, how we spend it, how we save and invest, and even how we keep records.

Beyond the supposed certainties of death and taxes, every part of our lives involves us in decisions in the face of an uncertain future. Every decision may produce any one of a number of results depending on what nature does (floods, droughts, hail); what other people do (decide to buy stocks, to go to the same movie at the same time and theater, to drive drunk); and even what our own bodies do (cramp up in cold water, turn out to be allergic to an exotic new food).

Given that we are uncertain about so much, it is not surprising that people have developed idiosyncratic rules of thumb—including rules that deny the existence of uncertainty—for dealing with necessary judgments and decisions. It is hardly less surprising that generations of academic and practical thinkers have turned their attention to the question: How *should* we to make decisions in the face of uncertainty? Finally, it may surprise a few readers, but not many, to learn that the answers suggested for this last question do not always match the ad hoc procedures generated by individuals as part of the business of getting by.

The method chosen for coping with uncertainty in many planning and policy-making contexts is simple if not very defensible: those involved pretend it does not exist. They plan, decide, and speak publicly as though their point estimates of the future would certainly come about. Think, for example, of discussions of the federal budget deficit. How often do these explicitly recognize the tremendous uncertainty with which the projection of government revenues and expenditures (and hence their difference) is laced?

While this approach surely hampers us in such fields as fiscal and health-care policy, we appear to be able to live with the performance penalty in return for the rhetorical simplicity. But when our policies impinge on nature and on the relationship among human actions, nature's responses, and the feedback from nature to human health and well-being, we do recognize the need to explicitly take uncertainty into account. Thus, we require

that dams, bridges, and culverts be designed and built with some specified small-probability rainfall events in mind. (At the other tail of that event scale, we plan reservoirs and emergency water supply facilities to protect us against lack of rainfall out to some chosen level of event rarity.) We set ambient environmental quality standards in terms that recognize that in some rare combinations of natural conditions they cannot be met at acceptable cost. Our regulations regarding sites containing improperly disposed-of toxic compounds also use probability-type statements (expected cancer cases per year in the local populations) in specifying the standards for cleanups.

In no field of public policy, planning, and management are the techniques for analyzing uncertainty better developed or more widely disseminated than they are for water resources. And in very few fields are the data required to characterize that uncertainty even close to being as rich in geographical coverage, time periods covered, and events measured.

On the other hand, roughly in parallel with our developing technical knowledge and skill, a realization has grown that there are often large and troublesome gaps between our expert calculations and the perceptions and rules of thumb of the lay public. This is troublesome because misperceptions and misleading rules of thumb can constrain society from opportunities for social gain.

There appear to be several different sorts of problems behind these gaps. Some seem to be more susceptible to solution through careful communication between the planners and experts and the public; some less. This manual has been designed to set out these problems in the context of the normative model for dealing with risk in decision making; to identify which problems may usefully be thought of as communication problems; and to suggest strategies and techniques for avoiding those that are avoidable or ameliorating those that cannot be avoided.

Purpose of This Guidebook

The purpose of this guidebook is to provide observations and theories about how people perceive risk and to set out guidelines that will assist water resource planners and managers in their efforts to communicate with the public and with decision makers about situations in which risk is important. Elements of risk and uncertainty are found in all areas of water resource planning and management. Different techniques for characterizing risk as well as different methods for identifying desirable strategies for dealing with risk are found in different areas. For example, standard flood damage analysis may be conducted using historical data on rainfall and streamflows in conjunction with knowledge of floodplain configurations and the nature of activities located in the floodplains. But, the extraordinary situation that would be created by dam failure does not lend itself to the same methods because historical data on actual failures is insufficient to produce useful probability estimates for specific dams and specific situations. Modes of failure must be analyzed in terms of individual contributing events and their probabilities. These probabilities will often be based on the professional judgment of experts in dam engineering The final analysis strings together these contributing events with assumptions about their independence (or, in some cases, their

correlations) to arrive at an overall probability of failure. Estimating the consequences of failure for the downstream communities will also require different techniques than will ordinary floods because of the nature of the flow resulting from dam failure.

Analogous contrasts can be made for navigation risks (where we may only imperfectly understand how obstructions are created, though we usually have good historical data on water levels and flows in rivers); drought (where predictions of weather over future weeks and months is key to management decisions, though we may lack forecasting skill extending beyond 3 or 4 days); and environmental management (where ecological-modeling capability may reflect substantial ignorance of how relevant systems, such as wetlands, actually function in the larger context as well as a serious lack of historical data on inputs and end points).

Other uncertainties such as political, institutional, and economic factors are even more difficult to explicitly incorporate. These factors are often influenced by the ability of state, local, and private entities to cooperate in the implementation of structural and non-structural measures (Hobbs 1987, Section 7).

Noting the importance of risk in water resource planning and management (and the requirements in *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (U.S. Water Resources Council 1983), hereinafter referred to as *Principles and Guidelines* or simply as P&G, the Army Corps of Engineers has developed a program to address risk including training, research, and field guidance. The Corps has held a series of workshops and training courses since 1987, that focus on how risk analysis can be useful in developing pertinent information for planning and decision making. In the area of research, the Corps has produced or supported several documents and reports including: *Risk-Based Decision-Making in Water Resources* (Stakhiv and Haimes 1986; Haimes and Stakhiv 1990; Stakhiv, Moser, and Haimes 1992), which provide a cross-section of risk analysis applications to various types of water resource problems; an Engineering Circular (EC) entitled *Risk Analysis in Planning*; and *Facing Natural Hazards: Uncertain and Intertemporal Elements of Choosing Shore Protection Along the Great Lakes* (O'Grady 1992). The Army Corps of Engineers has also developed several methods for assessing risk and uncertainty in various areas of water resources planning (Holliday 1987, Section 1).

Despite, or because of, these advances in the area of risk and uncertainty for water resources planning, the need for a manual regarding risk perception and communication remains. Both the decision maker's and the public's perceptions of risk from natural and man-made influences must inform the assessment of risk and uncertainty in the project planning process. In order to understand risk behavior, one must understand risk perception and how it may influence the use of technologies designed to reduce or control natural hazards.

Scope of This Guidebook

All perspectives on risk, including the perceptions of individuals, the public, as well as planners and decision makers, affect how risk is managed. This study begins with four

The purpose of this guidebook is to [illegible] observations and theories about how people perceive risk and to set out guidelines that will assist water resource planners and managers in their efforts to communicate with the public and with decision makers about situations in which risk is important.

concerns involving perceptions and behavior under risk and uncertainty. The four concerns are:

- The individual's and public's conceptualization or perceptions of risk, its measurement, display, and relevance to water resources analysis
- The public's exhibited behavior under risk as measured by appropriate instruments and its relevance to water resources
- Decision makers' attitudes toward and perceptions of risk given the typical choices and risk-cost trade-offs that are made in water resources
- The differences in public attitudes regarding comparative risk assessment among natural hazards and between the technologies designed to lessen the threats

Just as risk perceptions of individuals, the public, and decision makers may vary across particular natural or man-made hazards, effective methods of risk communication likewise may vary according to particular water resource-related projects.

Various water resource projects and the four concerns about perception will be considered in relation to each other and depicted through the six steps of the planning process. The six steps are important to consider, since assessments of risk may be influenced by the passage of time and the implementation of each of the steps of the planning process.

Corps Planning Process

The planning process of the Corps is a formal method of evaluation and decision making, outlining an orderly and systematic technique for project evaluations. Its six primary steps are:

- Specification of problems and opportunities
- Inventory, forecast, and analysis of conditions
- Formulation of alternative plans
- Evaluation of effects
- Comparison of alternative plans
- Plan selection

These six steps each include efforts to cope with risk by understanding the information relevant to the risk involved. The information pertinent to a project must be evaluated and understood in terms of its accuracy, relevance, and dependability. The Corps aims at achieving increases in national economic efficiency but realizes that both its information about the past and its projections of the future will always involve uncertainty.

Therefore, this process places special emphasis on informing and educating decision makers in the Corps and in federal, state, and local authorities, so they can fully evaluate the factors that weigh in the decision-making process. These relevant factors, as outlined in the companion guidebook to this manual—*Guidelines for Risk and Uncertainty Analysis in Water Resources Planning* (Greeley-Polhemus Group, Inc. 1992), are the (1) basic assumptions employed, (2) data and information analyzed, (3) unavailable data and information, (4) areas and degree of risk and uncertainty involved, (5) reasoning and rationale used in formulation, evaluation, and selection.

Handling Risk and Uncertainty in Planning

Let us begin by observing that it used to be common for "risk" and "uncertainty" to mean different things. Knight (1921) introduced the distinction between a situation involving risk, in which probabilities over the possible outcomes were known, and a situation involving uncertainty, in which they were not. Commonly, though by no means universally, today this distinction has disappeared because, as we shall see, the notion of probability has been broadened to include subjective likelihood judgments as long as these are made in such a way as to conform to the rules for probabilities.

Nonetheless, Section 1.4.13 of the *Principles and Guidelines* outlines the requirements for planners regarding the assessment of risk and uncertainty in the planning process. The P&G defines risk as situations in "which the potential outcomes can be described in reasonably well-known probability distributions, such as the probability of particular flood events" (p. 5). Planners are required to examine, then determine, the level of uncertainty in the data or the assumptions regarding "future economic, demographic, social, attitudinal, environmental, and technological trends."

The P&G also provides the following recommendations regarding the application and handling of risk and uncertainty:

- When working with related projects, the planner should attempt to use the same analyses and presumed probability distributions.
- Techniques utilized in determining risk should relate to the stage of planning.
- The planner should carefully select the variables that will be used in determining measurement error and sources of risk.
- Standard methods of risk evaluation may be used when risk can be characterized by a probability distribution that is based on firm data, such as hydrologic risk.
- The planner should explain why certain aspects of a project have been selected as areas of risk.
- Possible alternative outcomes should be developed utilizing sensitivity analysis (the process of changing assumptions then comparing the various outcomes).
- Subjective probability estimates may be useful in determining a spectrum of outcomes, but the report must clearly *identify these estimates as subjective.*
- Utility functions and public perceptions (if well known) may be used to suggest the best alternative design to decision makers. (P&G, pp. 15-6)

While this information is helpful, it does not provide full application guidelines for planners who have to characterize and evaluate risk during project development. In particular, it does not help in coming to grips with differences in risk perception between the public and the planners or with techniques for communicating with the public about risk. The heart of the problem—and the heart of the rationale for this guidebook—is that the individuals who make up this "public" neither perceive, nor respond, to risks in terms consistent with any narrow concept of rationality. In some situations, it appears that prerational or childlike responses are chosen;

The heart of the problem...is that the individuals who make up this "public" neither perceive, nor respond, to risks in terms consistent with any narrow concept of rationality.

while in others, so many facets of the risk are taken into account in making judgments that we might almost be tempted to call the behavior "super-rational." But only rarely will individuals easily and quickly buy into the models for coping with risk that we refer to as "normative." (These models are briefly reviewed in Chapter II.)

Organization

This manual consists of six chapters, a bibliography, and appendices. It develops a picture of what is known about the public's perceptions and reactions to risk and the best policies and methods of communication with the public about risk. An extensive bibliography is provided (under separate cover) for those wishing further information on these topics (Part II - An Annotated Bibliography).

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Chapter V deals with the effects of social pressure on risk perceptions and the potential for social amplification of risk perceptions.

Chapter VI is the heart of this manual. It provides guidelines for risk communication that represent the lessons to be drawn from the problems discussed in the previous chapters. Two objectives are distinguished. First, the objective of the planner is to provide the audience with a better understanding of the risk and uncertainty sur-rounding planning alternatives. Second, the objective of the planner is to encourage appropriate behavior by individuals and communities, especially in response to natural disaster.

Chapter II

Dealing with Risk: The Normative Model and Some Limitations

This chapter will begin with a brief review of normative (or, as they are sometimes called, "rational") models for decision making in conditions of risk and uncertainty. We assume that our audience has at least a nodding acquaintance with these methods. From that foundation we shall move on to examine the tensions between this benchmark and the most common perceptual and operational approaches exhibited by the public at large. These tensions may be thought of as arising from three broad classes of influence:

- Problems created by our ways of approaching life generally (emotional problems) and the results of our response to actual experience with risk or to communications about risk that reach us from our friends, neighbors, or colleagues, or from the media.

- Limitations on our ability to think as the detached experts say we should ("cognitive" problems for short)

- The conditions in which we find ourselves when called upon to make such decisions ("contextual" or "exogenous" problems)

Before we proceed, let us return very briefly to matters of terminology. We have already observed that the old distinction between risk and uncertainty is no longer generally observed, and in this guidebook we shall feel free to use the two words interchangeably. However, a potentially greater problem for us and for users of this book, because it is often hard to detect, is variation in the meaning of the work "risk" itself. For example, when we speak of "risk aversion" and "risk seeking" as descriptions of preferences, we shall not be referring to a dislike of uncertainty per se, but rather to a feeling related to the dispersion of outcomes and the changing value of the marginal unit of gain or loss across the range of outcomes. Often in the technical literature, however, "risk" means something even more specific. Sometimes it means the probability of contracting a disease (as in, "the cancer risk of smoking is..."); sometimes it means the chance of death or some other serious health damage for a randomly chosen member of a population from a cause or activity (as in, "the risk from superfund site x is 10-5"); sometimes it means the number of deaths per year from a cause or activity; and sometimes it means a complex amalgam of characteristics with no one measurement scale that characterizes an activity—its riskiness—as perceived by lay people. The best we can do is to try to be clear about the particular meaning we are attaching to risk in particular parts of the discussion. But the reader must be alert for variations in the meaning of risk in other sources of information.

Rational Models for Dealing With Risk

Let us begin by assuming that our interest in risk arises from the necessity of choosing among alternative programs, policies or projects when the outcomes that follow from the choice are partly determined by events over which we have no control and that, indeed, appear random to us. To illustrate, let us be more specific and assume that we are required to choose among three alternative projects competing for investment dollars (A, B, C). Further, assume that the actual results from choosing any one of the projects depend on which of many alternative possible "states of nature" (1, 2,....,n) is actually experienced. Thus, these states are exogenous to our choice but, jointly with that choice, determine the net benefits accruing from it. Also assume we have quite complete information, including an estimate of how likely each state of nature is to occur,[1] and estimates of the payoffs (net benefits) that accrue when a project is chosen and a state of nature occurs. Thus, we have at our disposal information about what *could* happen, depending on how we choose. That information might be summarized in a matrix of payoffs like that in Table II-1.

We may also know what the probabilities of nature's choices are. That is, we may know that event 1 occurs 50 percent of the time, event 2 occurs 30 percent of the time and event 3 occurs 20 percent of the time. Where these probabilities might come from will be discussed later. For now, we can think of them as reflecting historical experience.

The fundamental problem of choice under uncertainty may be thought of as arising because, in general, no project will have payoffs in all states that are at least as large as those of any other project choice. If such a project does exist, there is surely no point in doing other than choosing it. But in the inconvenient "real" world such a trivial version of uncertain choice is rarely seen. Thus, in the payoff matrix (Table II-1), we can see that no project dominates. A is the best choice if we are certain nature will choose event 1. C is the best if we know in advance that event 2 will occur, and so on. But, the essence of risk is that we do not know.
To try to make the nature of the problem a little clearer, let us think about the design and construction of a levee that will protect a small town from flooding. Two things are obvious: a higher levee will cost more to

Table II-1

Matrix of Payoffs (Net Benefits)

		Nature "Chooses" a State or Event		
	Project	**1**	**2**	**3**
We	A	5	4	0
choose	B	2	-10	9
a project	C	-2	6	6

[1] It is not essential that either the possible states of nature or their likelihoods be independent of project choice, but it is certainly simpler for this review.

construct; and a higher levee will offer protection over a greater range of possible flood crests. If we knew in advance how high the crests would be during the planning horizon, we could choose the "best" height. It would be the one that minimized the sum of the costs of levee and the remaining damages from flooding.

A very simple version of this problem is presented in Figure II-1, where we distinguish three levee projects A, B, and C of progressively greater height. In Figure II-1a we show the costs of each levee and the damages that would occur in the "protected" town at various river flood crest heights. (For simplicity we pretend we are interested in only one event, what we might call the design flood for the project.) The hypothetical damage curves assume that damage is zero until the levee is overtopped at which point substantial damages are incurred immediately. As the height of the crest rises above this level, the damages increase more than linearly, and at some enormous crest height it no longer makes any difference which levee was built.

In Figure II-1b we bring costs and damages for the hypothetical projects together, showing their sum in each case. And, most importantly, we show that over different ranges of crest height, different projects dominate. If we *knew*, for example, that the maximum crest height would be between C_0 and C_1, we would build levee B. But we do *not* know. Nature sends us no memo of intent, though we can observe nature's actions and, if we have been doing so for many years, we can infer something about what might happen in the future. These inferences are the source of probability information—information about the likelihood of crests of particular heights.

How do we decide which project to undertake then? In brief, we have to seize on one state of nature or one payoff for each project, or we have to summarize all the information we have into one number per project. Some alternative rules:

- Look at the worst nature can do and pick the project that produces the best result in that situation, realizing that (a) this may be very unlikely, and (b) if another state, perhaps any other state, actually materializes, we will probably regret our choice.

- Look at the worst result for each project and pick the project that gives the least serious of these worst outcomes. Picking the project that gives the least serious result is very conservative and puts a limit on our losses.

- Pick the project that gives the best of the best results. This is a very aggressive strategy and ignores the possibility of a truly horrific loss. Neither method makes any use of the probability information we assumed to be available.

- Another option is to create a summary measure using all the available information. Called the expected value, it would be calculated for each project. For the payoff matrix (Table II-1) and the probabilities set out earlier in this section, the expected values of the net benefits are as follows:

E(Project A) = .5(5) + .3(4) + .2(0) = 3.7

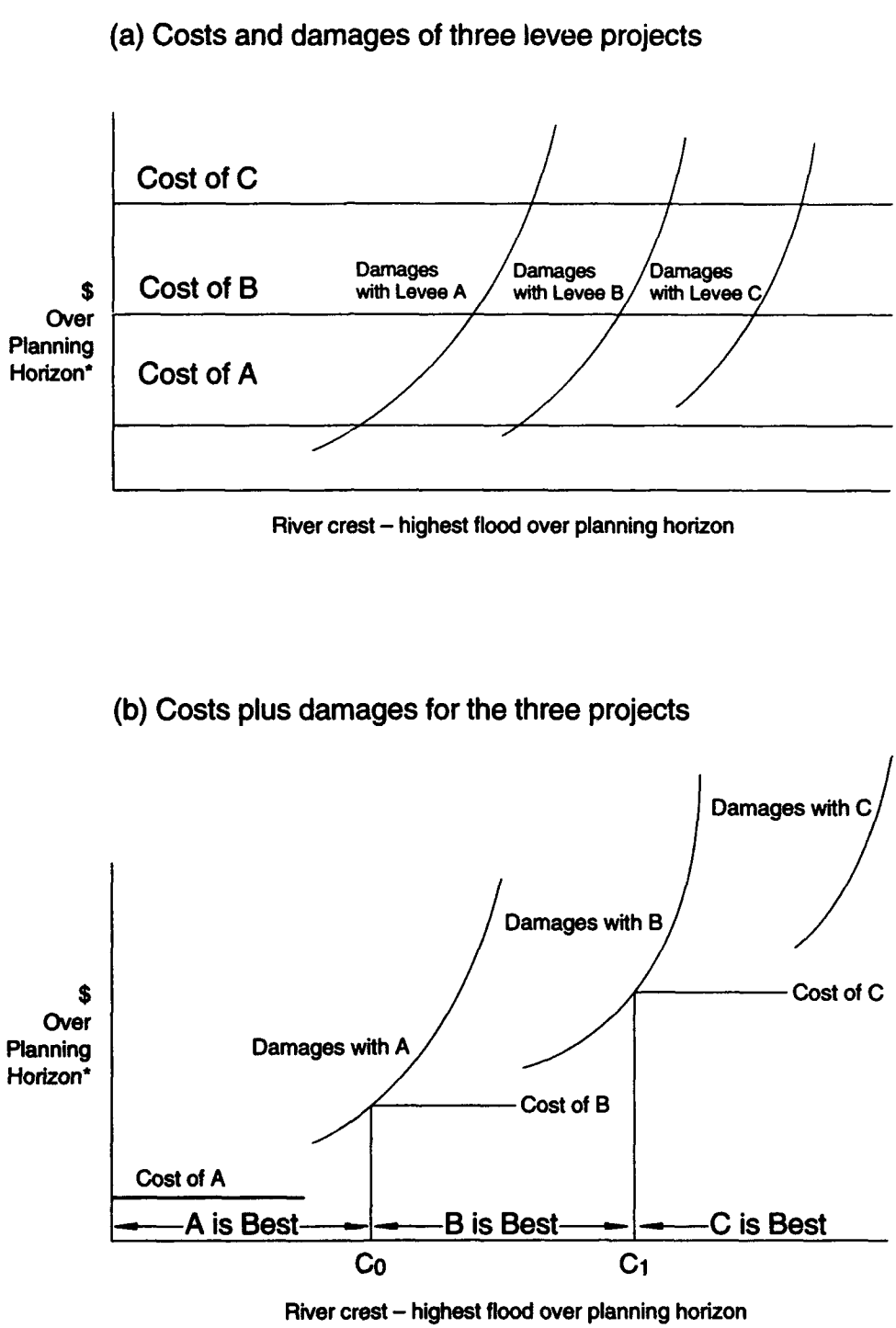
E(Project B) = .5(2) + .3(-10) + .2(9) = -0.2

E(Project C) = .5(-2) + .3(6) + .2(6) = 2.0

If we knew in advance how high the crests would be during the planning horizon, we could choose the "best" height. It would be the one that minimized the sum of the costs of levee and the remaining damages from flooding.

Figure II-I

Costs and Damages as Related to Project Choice and Natural Event



*An added complication, ignored here, is that we do not know when any flood will occur.

And by this criterion, project A is best. More generally, the expected value of any project is the sum of the probability weighted outcomes over all possible states of nature; or, for continuous probability density functions, the integral over the range of possible outcomes of the product of the density function and the net benefit function.

As we note below, this simple summary measure can be elaborated for cases in which the gap between maximum losses and maximum gains is so large that we might want to weight losses more than gains (or even vice versa). It is also possible to elaborate on the methods that seize on one particular payoff, and indeed, we can even decide what to do by trying to anticipate how badly we will feel (how much we will "regret" our choice) when our decision is actually stacked up against nature's choice.

But to go back to the expected value criterion as representing the method of choice, we observe that there are several ways to understand what it means, any one of which may be helpful to any particular person. If we begin by asking how we might use all available information, we can see that this technique seems an intuitively sensible answer. We have weighted our information about the possible results using our information about the relative likelihood of our experiencing any particular result. If, on the other hand, we think about the problem as though we could repeatedly run an experiment in which we choose and then nature chooses, and finally we observed a result, the criterion just discussed can be seen as our best predictor of the average of all the results observed in that series of experiments.

In this latter connection, however, it is important to note that this "expected value" measure is *not* a prediction of the result that will actually be observed in any particular experiment. So that if we have a single decision to make, the expected values of the alternatives are not predictions of outcomes but simply agreed upon criterion values for ranking the decision alternatives. One very easy way to understand the difference between prediction and expected value is to think of rolling a fair die. We can predict with certainty only that the result will be either a 1, 2, 3, 4, 5, or 6 on the top face. We can "predict," as we do in games involving dice, that some particular face will come up, but we have only one chance in six of being proved right in a particular trial. On the other hand, the expected value of the operation: toss one die and record the top face is $(6 + 5 + 4 + 3 + 2 + 1) \div 6 = 21 \div 6 = 3.5$. This can *never* be the result of any single trial of tossing the die. But if we toss the die 1,000 times, record the value of the top face each time, add the results, and divide by 1,000, the result will be very close to 3.5.

...the expected values of the alternatives are not predictions of outcomes but simply agreed upon criterion values for ranking the decision alternatives.

It is very easy to construct examples in which agreeing to use the expected value criterion leaves us very uncomfortable. It is also possible that some readers will be uncomfortable with the notion of a probability distribution over outcomes. Therefore, let us briefly consider these two areas of discomfort.

In some applications, even government agency applications, in which gains are not personal and bankruptcy is not a possibility, decision makers may want to put a greater weight on large losses (e.g., large losses of life and property in a flood) than on large gains (e.g., from recreation days experienced on a

full flood-control reservoir). In such circumstances, it is possible to introduce another weighting function—economists often refer to it as a utility function—that is tailored to the feelings of the decision maker in question. Or it may be instructive to try several different weighting functions and see how sensitive the implied choice of project is to the choice of function. A typical weighting function displaying the conservative bias known as "risk aversion," is concave to the results axis—that is, it increases as results increase but at a slower and slower rate.[2] Such a function is displayed in Figure II-2.

...it does make sense not only to talk about but also to use probabilities, even when these are "subjective"—based on judgment...

Now, what about probabilities? It may seem to be one thing to talk about probabilities where coins and dice are concerned, something slightly different where local rainfall and streamflow are the states of nature, and quite another when we have to cope with a question of possible massive structural failure (e.g., collapse of an earthen dam). In the first case, probabilities are determined by simple physics and the shapes of the chance determiners, (e.g., we ignore the infinitesimal probability that a tossed coin will land and stay on its edge, and we argue, a priori, that unless it has been tampered with, either side down is equally probable.) In the second case (hydrologic), we can look at quite long historical records—at least we can in most places in the industrial economies. Using more or less sophisticated techniques we can extract the information in that record and obtain estimates of the relevant process probabilities—for example, a continuous probability density function for rainfall or streamflow someplace.

But in many important decision contexts we have either no record or a very short record, while simple physics will not carry us very far. (This is the origin of the old risk-uncertainty distinction.) Does it make sense even to talk about, let alone to use, probabilities in such cases? Many, though by no means all, of those who have thought deeply about this subject believe that answer is yes, it does make sense not only to talk about but also to use probabilities, even when these are "subjective"—based on judgment and experience rather than physical laws or data. In complicated cases, such as the dam collapse possibility, it may be necessary to break down the path to failure (decompose the risk) into small steps that different individuals can wrap their minds around, and later, to combine many judgments into an overall probability that all the failures necessary to produce a major accident would occur.

There are also established methods for updating subjective probabilities as experience and information accumulate (Bayes' theorem. For an example, see Parzen (1960) and in Chapter IV.)

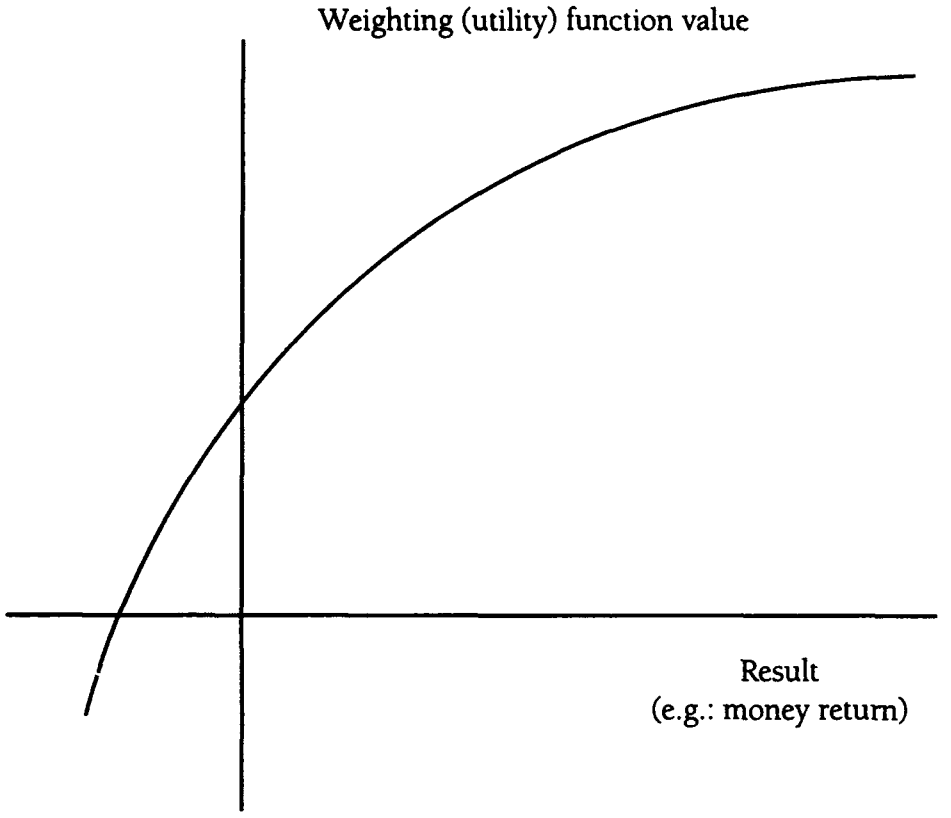
Not-So-Rational Models: Why Do We Care?

We have tried to emphasize that the description above is fundamentally normative (prescriptive)—a matter of what we *ought* to do when we make decisions under risk. There is, however, a considerable body of evidence suggesting that individuals do not always, or even usually, follow this prescription. The catalog of human failings in this regard is long and will be discussed in

[2] This notion, originally called "moral expectation," was introduced into the probability literature in the eighteenth century by Daniel Bernoulli as a way of understanding why people are not willing to pay infinite amounts to play games with unbounded expected values (the "St. Petersburg Paradox").

Figure II-2

Illustration of a Weighting Function for Outcomes Under Risk



more detail in the chapters that follow. But for present purposes consider just a few items from it.

- Many individuals have great difficulty understanding the fundamental concepts of uncertainty or randomness—especially the notion of "independence" between two such events (e.g., between the first ten tosses of a coin and the eleventh). Thus, it is common for people to believe that if ten coin tosses in a row come up heads, the probability of a tail on the eleventh toss will be substantially greater than one-half. This conviction is related to a garbled version of what is known as the law of large numbers, where the garble involves imputing a will and a memory to the coin so that it "knows" its record over the past ten tosses and somehow "acts" to push the cumulative record back toward the long-run predicted result of one-half heads and one-half tails.

- In more complex situations, such as those created by the uncertain forces of weather, individuals will often personify an analogous sort of memory. For example, the research of White, his students, and students of his students (Burton, Kates, and White 1978; Kates 1962; White 1964)

has shown that many people view natural hazard events such as flood, drought, hail, and tornadoes as being sent by a conscious Being who somehow keeps track and would not send one flood on the heels of another. Others see such events as cyclical, where again the occurrence of the event guarantees a period free from it.

- Even when they understand probabilities and how to use them, people commonly overweight low probability events—that is assign a "decision weight" to low probability events that is higher than the "objective" or "true" probability of the event (Kahneman and Tversky 1982).

- Individuals are highly susceptible to nuances of situation framing in deciding between alternative gambles. (e.g., concentrating on expected fatalities in one framing leads to different preferences over the same gamble than does concentrating on expected lives saved (Kahneman and Tversky 1982; Tversky and Kahneman 1981)).

- Subjects in laboratory experiments commonly exhibit preference reversals over gambles—that is, they commonly act irrationally in the face of uncertainty by, for example, saying they "prefer" lottery ticket A to lottery ticket B (where A differs from B in probabilities and sizes of winnings) but then indicating a higher willingness to pay for B rather than for A (Lichtenstein and Slovic 1971; Slovic and Lichtenstein 1983; Grether and Plott 1979).

Thus, we can see, at least in a preliminary way, that there is reason to expect to find that lay citizens will not always—indeed, may never—follow the dictates of any normative method in making their own decisions about what to do in risky situations. They may misjudge or misunderstand probabilities. They may focus on some irrelevant or emotional facet of the problem. Or they may mean different things when they use words such as "prefer" and "willing-to-pay" than experts assume they ought to mean.

Not-So-Rational Models: Problems For Public Agencies

In the context of purely personal decisions, no one but the decision maker stands to lose from the use of a flawed version of the normative model. If an individual wants to gamble on coin tosses while assuming the coin in question has a memory and a will, that is his business. (Economists may be upset because this calls their entire model of the rational, self-seeking individual into question, but hardly anyone else will care about that.) If another individual allows small differences in the words used to describe his problem to influence his decision, he pays whatever price is involved. But the number of decisions that are purely personal is surprisingly small, once we begin to take account of the many forms of interdependence implied by such features of modern society as crowded streets, buildings, and highways; public (tax) financing of much health care; and welfare programs aimed at preventing the worst ravages of total poverty. In such societies, driving while drunk, for example, endangers not only the driver but also others on the road, and the cost of any care required for resulting injuries would likely be shared generally across society through such programs as medicaid or through the shifting of charitable-care costs to privately insured patients. So, even what

might seem on the surface to be a private decision about taking risks can have diffuse social consequences. Therefore, all citizens have, in principle, an interest in how those decisions are made. They would, if they could be asked, presumably say that accurate information and sound methods should be used.

An agency such as the Corps of Engineers, charged directly with the spending of public money to achieve public ends, has an obligation to use accurate information and sound methods in dealing with the uncertainties that face it. But its decisions cannot in general be made and imposed unilaterally. It therefore has an interest both in understanding how the private citizens with whom it interacts make their decisions and in encouraging the use of the best available methods and information by those citizens. Consider a few hypothetical but not farfetched examples:

- The Corps is planning a flood-control reservoir project and finds, using the best available historical hydrologic data as well as sound methods for evaluating flood damages avoided, that the proposed dam seems to be justified in National Economic Development account terms. But toward the end of the planning cycle, a severe flood occurs (say the 500-year flood). The residents of the region, hearing "500-year flood" and subscribing to the cyclical view of natural hazards, oppose the dam as unnecessary because another flood is not "due" for about 500 years.

- Another dam project, with a similar purpose, runs into trouble with the local population that must provide cost-sharing when an existing dam on another river, of different type and sited in different geological conditions, fails. For the population, the news of one dam failure has led to a large increase in subjective probabilities of dam failures generally.

- The Corps, in an effort to explain the benefits of yet another dam project, talks publicly about numbers of flood deaths occurring with or without the dam. People's feelings about the project may indeed be affected by the use of a "deaths occurring" frame rather than a "lives saved" frame.

- The Corps is considering a request for a Section 404 permit that involves a wetland drainage scheme. Its consideration will include an examination of prospective ecological damages to the wetland. Ultimately, the Secretary of the Army's position on the permit will have to be based, in part, on the expert judgment of ecologists about the probabilities of various types and levels of harm. But there is no requirement that even entirely rational citizens should also accept these judgments. Further, there is nothing that says these citizens should accept an expected value decision criterion as the appropriate one for such a decision. Many concerned individuals might indeed prefer a more conservative criterion, such as acting to minimize maximum possible damages.

The message of these examples is that simply understanding the classical normative model of risky decision making is not enough for a public agency that must interact with a range of citizens in order to do its job. Such an agency must be prepared to find its plans criticized on the basis of apparently irrational

...there is nothing that says these citizens should accept an expected value decision criterion as the appropriate one... Many concerned individuals might indeed prefer a more conservative criterion, such as acting to minimize maximum possible damages.

fears (or equally irrational overconfidence); to have its judgments questioned by outside experts; and to have its decision methodology rejected as insufficiently conservative (or as too conservative) by the public.

Concern about exactly this problem—disconnection between expert or agency assessments of and recommendations for risky situations—has inspired a substantial amount of literature (For recent examples, see Institute for Philosophy and Public Policy 1988 and Slovic et al. 1991). Much of this literature has a tone in which condescension and frustration seem mixed in equal parts. "Why can't they be more like us?" expressed Professor Higgins' frustration with the ways of women; it might stand for the technocracy's feelings toward the public's ability to deal with risk.

...not everyone who qualifies as a "public" decision maker...also qualifies as an expert in understanding uncertainty.

Two points, however, must be stressed by way of putting this concern in perspective. First, not everyone who qualifies as a "public" decision maker—certainly not every legislator or executive or regulatory agency head—also qualifies as an expert in understanding uncertainty. Thus, this individual human frailty is doubly a matter for collective concern. But second, and at least as serious, there are reasons to be concerned even about the experts in our public decision-making structure. Consider the following:

- Sometimes expert expressions of confidence (of the low probability of hazard) seem to be related to political and financial pressures to keep programs on track. For example, NASA's official estimate of the probability of shuttle failure, 1 in 100,000, is wildly different from the recorded rate of 1 in 25 or 1 in 50, depending on the calculation used (Freudenburg 1988, p. 47).
- Even in more mundane and familiar settings, experts may be quite unreliable judges of risk. Freudenburg (1988) reports on studies of the inability of physicians to diagnose disease from case histories and examinations and on the inability of geotechnical engineers to predict correctly the height of an embankment that would cause a clay foundation to fail.

And even when bias and lack of skill are both absent, experts may face very fundamental constraints on their ability to deal with risk. For example, philosophers of science talk about "interference effects" that may occur when technologies are combined in new ways. It may be impossible to predict when such effects will occur and what form they will take (Applebaum 1977; Hacking 1986).

Thus, there appear to be several difficulties even with expert risk assessments. Whatever rules of thumb the lay public may use to assess the assessors, it would be surprising if there was collective agreement to put a "decision weight" of one on expert predictions of risk. Since in many of the situations that form a backdrop for the "we-us" lament, there is at least some reason to see corporate or agency self-interest served by low levels of risk prediction, much higher levels may well enter individual calculations with nonzero weights. In the presence of such fundamental defects in our knowledge, skepticism and conservative rules of thumb may seem only prudent even to educated, objective, and unemotional members of the public.

The final nail in the coffin of hope for rational public decisions about risk has been thought to be that if there were no a priori rational grounds for devaluing a particular risk

assessment, the public would still be in a sense unreachable. The combination of faulty understanding of risk, flawed manipulation of new information, and tendencies to try to take the probabilities out of risk would form too powerful a block to learning. While this may yet prove to be so, there are fragments of evidence that, at least where people see their self-interest immediately involved, careful attention to the details of risk communication can make a useful difference (Bohm 1990; Smith et al. 1990).

But in order to take advantage of opportunities for careful communication, it is necessary to understand where these many sources of controversy come from. On the basis of that understanding, it should be possible to develop strategies aimed at making the final collective decision on any program or project as rewarding as possible for society at large. To those twin ends—understanding and strategy formulation—the rest of this chapter provides a brief overview of sources of difficulty with the rational model. Some of these sources are internal to individuals, and some of these in turn represent cognitive or logical failures, while others are simply produced when different individuals make different choices and use different criteria for choosing, all equally valid and internally consistent. Some difficulties arise, on the other hand, because in stressful situations, emotional modes of thought and behavior may take over. And still others are produced by social pressures and interaction. Chapters III-V go into these problem areas more carefully, as preparation for the final Chapter VI in which lessons for action are drawn from the catalog of difficulties.

Sources of Tension Between Experts and Public in Risk Analysis

To provide some structure for our catalog of difficulties, or rather, we should say, the causes of differences between individual and agency answers to questions of how to respond to risk, we provide the schematic of Figure II-3. This shows the individual as having two sources of information about risk: direct observation of risks and communications that describe risks. By "direct observation" we mean such opportunities as living through years of climate and weather in a particular location; driving an automobile on particular roads at particular speeds; taking specific drugs; eating foods; watching the processes of birth, growth, and death in other humans; and so forth. Much of this observation provides us with information about the risks we are running and most of us make at least some effort to process and extract that information.

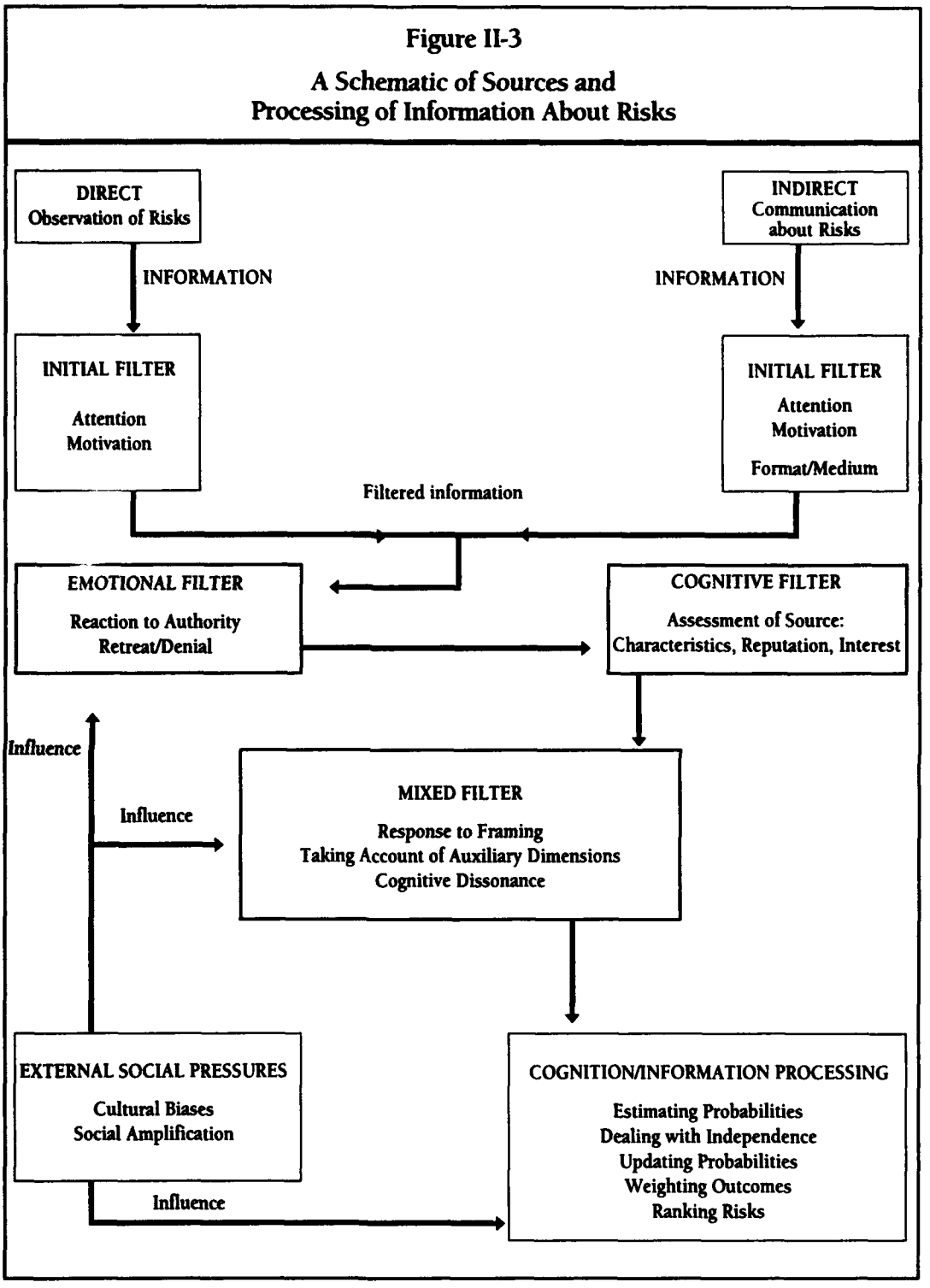
...in order to take advantage of opportunities for careful communication, it is necessary to understand where these many sources of controversy come from.

We also have available a massive amount of indirect information about risk—indirect because it has been processed by others and then communicated to us in words, numbers, pictures, or mixtures of those means of communication. Indirect sources include all of the mass media (TV, radio, newspapers); stories and reports brought to us by other individuals; specially targeted efforts to inform us, such as newsletters from concerned groups, from companies that want to sell us a service or product, and from public agencies that want us to share their view of a particular situation or policy.

Both our own observations of, and the indirect communications we receive about,

Figure II-3

A Schematic of Sources and Processing of Information About Risks



risk may be thought of as subject to several filtration stages. Initially, we filter out information that arrives when we are too busy to be attentive, or that does not seem to speak to our personal situation. For example, information about tornadoes in Oklahoma may not be attended to if we live in Massachusetts and have never seen or heard of a tornado touching down anywhere nearby. Reports of the dangers of rock climbing, long-distance swimming, or urban rollerskating may well be filtered out if we have no intention of ever pursuing any of those activities. But even a TV news report of flash-flooding danger in our local area many be essentially ignored if we are trying to balance a recalcitrant checkbook when the report appears on the TV news. In the case of indirect communication about risk there also seems to be another initial filter, one triggered by the medium containing the message. As an extreme example, consider junk mail and phone calls. An individual may very well have decided to ignore all such messages and may throw away the one and hang up on the other without receiving even a fraction of the intended message. Similarly, some (even many) individuals may change radio or TV stations when an informative talk show comes on. Others may read only certain parts of their newspapers, be it comics, sports, business, or editorials.

The next layers of filtration act on information that has "survived" the first filters and entered our consciousness. These secondary filters may be thought of as determining how the surviving information is classified and interpreted in preparation for processing. (The order of these filters in Figure II-3 does *not* reflect any sophisticated model of human consciousness, emotions, and intellect. It is merely meant to be suggestive and an aid in interpreting the sorts of problems that have been observed and commented on in the field.) We distinguish three sorts of filters: emotional, cognitive, and mixed.

The idea behind the "emotional" label is that we are sometimes not so much thinking about what we see or hear as simply reacting, perhaps in rather primitive ways, to the information that has reached us. Two principal types of reaction we distinguish are, first, to the information itself and, second, to the source of the information. The first reaction may result if in fact that information is very threatening. For example, a story about the dangers of smoking could be very threatening to a heavy smoker. Similarly, stories about flood risks threaten floodplain inhabitants and observing a bad automobile accident threatens a person who habitually drives very fast or who drinks and drives. Such immediate threats may, as discussed in more depth in Chapter III, trigger retreat and denial—refusal to think about the problem or to take steps to reduce the threat.

The second broad sort of reaction is to the source of the message. An especially complicated cause of such reactions may be the connection formed by the individual between the threat implicit in the risk information and the authority that is perceived to be its source. This reaction may well take the form of rejection of the information because the source of the information is seen as having betrayed or abandoned the individual receiving the message. In effect, the authority is seen as parent to the recipient's child; and a failed parent at that because it is merely informing about a risk rather than "fixing" it.

...we filter out information that arrives when we are too busy to be attentive, or that does not seem to speak to our personal situation.

A second filter between receipt and processing of information we call "cognitive" to emphasize that sophisticated thought and reasoning are involved in its application. A major activity of this filter is to judge the combination of message and source and check for grounds for rejection. As a very simple example, consider an individual who encounters an advertisement in a major news magazine that tries to explain that concern about exposure to carcinogens in food has been blown out of proportion, that the increased risk of some of the better-known scare examples is so tiny as to be nearly undetectable across large populations. The cognitive filter checks the source of the ad. If it is Monsanto, skepticism may dominate the reaction. If the ad has been jointly sponsored by Monsanto and the Environmental Defense Fund, a very different response will probably be called up. In general, this filter may be thought of as an examination of the message-institutional source pair in terms of such characteristics as the perceived fairness and balance of the message; apparent sincerity of the message; the likely objectivity of the source; and the apparent competence of the message construction. Failure of the pair to pass some part of this examination may relegate the message to the wastebasket as surely as if it had arrived in a piece of junk mail, even if considerable expense has been put into putting the message in a popular medium.

We label the third filter "mixed" because it seems that elements of both emotions and cognition are involved in its processing work. The examples we give in Figure II-3 of this filter's activity include the resolution of cognitive dissonance, the response to particular aspects of message framing, and the construction of what we might call "situations contrary to fact" out of the risk information received. The first of these activities, the resolution of cognitive dissonance, has been recognized for many years as a very human information processing activity (Festinger 1957). Roughly, it is what we try to do when new information conflicts with current beliefs or emotional positions. For example, an individual is emotionally and financially committed to a major environmental group, but the group takes a position on the risks from a specific farming practice or chemical that objective sources of information seem to agree is dead wrong. How does the individual respond? By filtering out the objective information on the grounds that it is only apparently and not "really" objective? By abandoning belief in the group? Or by some quite sophisticated internal admission that the group, while worthy of continuing support, was surely wrong on this call? A similar difficulty would arise for an individual whose livelihood was threatened by a policy suggestion that intellectually, the individual knew to be socially desirable. In such situations, something has to give, and often it appears to be the emotional position that ends up dominating behavior.

Response to framing is another well-studied phenomenon of the literature on individuals and risk. Simply put, the evidence is that many, though by no means all people, will respond differently to two mathematically identical pairs of risky choices if one choice pair is couched in negative (e.g., loss of life) terms, and the other is stated in positive (e.g., saving of lives) terms. We attribute this difficulty to the mixed filter because it is clearly not a purely cognitive phenomenon but has something to do with our emotional responses to the terms being used.

The third activity we categorize as part of the operation of the mixed filter is related to the response-to-framing problem but seems to be worth a separate mention. We call it the construction of situations contrary to fact. The best examples of this come from laboratory experiments and other investigations of the problems that individuals have with risk, and we describe these and give examples in Chapter IV.

In Figure II-3 we show the information that survives and is modified by the filtration processes going to a cognitive processing operation. In this operation an individual uses the surviving information to estimate and update subjective probabilities of the events in question (flood, lung cancer, auto accident, or whatever); to deal with the implications of stochastic independence where that is relevant (as it certainly is with fair coins and other gambling devices and is generally thought to be for most naturally hazardous events); to construct auxiliary weighting schemes for outcomes (technically often referred to as utility functions); and to rank risks and make decisions about behaviors and choices. In all these operations we observe further difficulties that imply that policies and projects decided on the basis of expert judgments and agency weighting criteria may well not be acceptable to lay individuals. Consider, for example, the following list, and see Chapter IV for more detailed discussion:

- The evidence indicates that individuals tend to overestimate the probability of rare and spectacular events and to underestimate the probabilities of common and more pedestrian risks. This may be related to the way these different sorts of events are treated by the media.

- Once a probability of an event is formed and new information bearing on that probability becomes available, individuals have difficulty making the called-for adjustments. Technically, this should be done using Bayes' theorem, which not 1 person in 10,000 has probably ever heard of (see Chapter IV). But even allowing for the necessity of using rough, intuitive methods, it appears that people make incorrect judgments about how important particular bits of information are. They may, for example, overvalue in their revision the results of one test, ignoring the information about the test's diagnostic powers; or they may seize on some information that appears to "explain" how the events in question occur.

- As already noted, people commonly have a great deal of trouble with the notion of independence and appear ready to go to considerable mental lengths to construct theories that deny independence in risky situations that involve repeated trials or the simultaneous occurrence of several events.[3]

- While no subjective weighting scheme for outcomes can, a priori, be said to be wrong or illogical, some are more intuitively appealing than others and some are more obviously consistent with observed behavior than others. A pattern that researchers find with surprising frequency is nonintuitive indeed: this is a pattern expressing

...evidence indicates that individuals tend to overestimate the probability of rare and spectacular events and to underestimate the probabilities of common and more pedestrian risks.

[3] A joke that uses this proclivity for its humor involves the person who tries to board a plane with a bomb in his briefcase. When caught, arrested, and questioned, he explains his behavior by saying that he'd heard the chance of a plane having a bomb on board was 1 in 10,000. He figured the chance of there being 2 on this plane must be 1 in 100 million; so he was just increasing his and everyone else's safety.

aversion to risk when gains are at stake but a seeking of risk when losses are in question. (As discussed in Chapter IV, however, there is a problem in trying to infer weighting patterns from observed behavior when probabilities are also subjective and subject to the problems caused by the difficulty of accepting independence.)

- Perhaps the most damaging phenomenon of all to the notion that lay people can deal rationally with uncertainty is one already referred to—that well over a majority of subjects in laboratory tests exhibit what is known as "preference reversal." This occurs when they are asked to give a preference between two lottery tickets and subsequently to say what price they would have to be paid for each ticket to give it up if they owned it. When the choice is between two tickets that have similar *expected values* but very different dispersions of potential winnings, individuals commonly express a preference for the ticket offering lower dispersion, even if its expected value is also a bit lower. But when asked for the prices they would require to sell each of the tickets if they owned them, these same individuals commonly name a higher price for the wider dispersion ticket. Since we normally think that "preferred-to" and "would-want-a-higher-selling-price-for" amount to the same thing, these experiments seem to many to suggest that people become hopelessly muddled when faced with risky decisions.

Perhaps the most damaging phenomenon of all to the notion that lay people can deal rationally with uncertainty is...known as "preference reversal."

The final box in Figure II-3 is that labeled "external social pressure." It is shown as influencing the outcomes of all the filter operations and of the cognitive processes. Within the box, two specific forms of social influence are noted: cultural biases and social amplification. The first is meant to suggest the range of possible influences on behavior under uncertainty that come to us with the belief system we adopt from the culture we grow up in. For example, a person raised in a fundamentalist Protestant religious household may be ready to see God's hand and God's judgments in natural events. This makes it hard for such a person to see that the normative model for dealing with, say, flood risk, is of any use. On the other hand, Western culture generally enshrines the power of human scientific and technological knowledge and assumes that we can eventually know nature's secrets and control nature's processes. This bias, too, may make it hard to accept ran-domness and independence associated with natural events.

The second aspect of social influence, social amplification, is a more subtle but also perhaps a more powerful notion. It involves the reactions of individuals to events, both as individuals and as members of hierarchies and groups, and the interaction of those individuals with others in such a way as to amplify the perceived threat from the event. ("Amplification" is used here in a generic sense of changing the strength of; the process may lead in either direction of increasing or decreasing the general perception of risk.) An example of amplification in the plus sense could be found in a situation in which local politicians pick up signals of concern from constituents about a proposed dam, for example, and, stressing the dangers, bring this to much wider attention while giving the concerns new legitimacy. This feedback loop could in fact be engaged for another round or two and lead to massive rejection of the required local financing.

With this introduction and framework in place, we now turn to a more careful and detailed catalog of difficulties with, or limitations of, the normative model for making risky decisions.

Filters for Risk Communication

Chapter III

The informal model of risk perception and analysis that we sketched in Chapter II emphasized the role played by "filters" between external stimuli and internal information processing. These filters operate both on the risk information gathered directly by our own senses and on information about risk provided to us by others as, for example, in television documentaries, magazine articles, and conversations with friends. And the filters seem to be created to serve different ends, some apparently more useful to the individual than others. For example, one sort of filter may prevent new information from being noticed or remembered seemingly in order that concentration on other, more immediate concerns will not be lost. Another sort, on the other hand, may change the nature of the information that gets to the brain's processing operations to make it consistent with a comforting, but not necessarily serviceable, version of what is being observed.

We divided these filters into four broad types: the initial or consciousness protecting, the emotion-based, the cognitive, and the mixed emotional and cognitive. Within each type we distinguished more than one motivation for the filtration action and more than one possible outcome of the filter's operation. In this chapter, we go over this material more carefully.

Initial Filters

It is possible to gather some information from our own, direct experience. For example, those of us who grew up in the 1940s and 1950s were more likely than not to have watched one or both of our parents smoke regularly. If those parents have died—or if they have been treated for cancer, emphysema, or heart disease—we have an observation, in retrospect, on the health risks of smoking. (We also have an observation if they are still living and in good health; an observation with a very different message.) Or consider climate risks. The longer we have lived in one place, the more observations we potentially have on such climatic and weather risks as flood, drought, hail, hurricane, and tornado. And as a final illustration of the notion (without any claim to having presented a complete catalog), think of the thousand and one risky things each of us does every week from commuting by automobile to operating power tools, from taking drugs (prescription, nonprescription, alcohol, caffeine) to exercising irregularly and under stressful conditions. Each such action and its consequences constitute an observation that can help us form our own judgments of the risks we are running.

On the other hand, by far the greatest amount of information available to us about almost any risk we care to name comes to us indirectly: from friends or acquaintances reporting on their experiences, from the media of mass communication, or from a third- or fourth-hand account that relays to us the content of a story in the media. In interpreting our own, direct, experience, we inevitably suffer from the problem of small

sample size. Furthermore, although we may have some personal experience with many risks, there are inevitably many, many more that we can know nothing directly about—whether because we actually do not have relevant experiences or because we do not know what our experience is. Thus, it is very unlikely that any given U.S. citizen has any direct experience relevant to assessing the risks that nuclear power plants pose. And while we may all be walking "observations" on the dangers of pesticide residues on food or of lead in the general environment, we would be very unusual if we actually knew anything at all useful about our experience. Thus, for most areas of modern life relevant to agency responsibilities, our risk perceptions are likely to be more a product of our exposure to indirect information—especially stories and analysis in the mass media—than of personal experience.

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Attention

For both sources of information, similar initial filters are usually in operation. We have called these "attention" and "motivation" filters. In simplest terms we mean to suggest that whether or not a direct experience or an indirect message about the experience of others is used to construct a judgment about risk depends, first, on whether we attend to it, and second, whether we are motivated to make use of it. Our ability to attend depends on what else we have to do or think about. At the extreme, an obsession with a career or marital problem could effectively block messages from nearly every other aspect of life. More usually, if we are devoting considerable attention to one task or interest, we do not have attention "left over" for much else. The example we used in Chapter II was balancing a checkbook, but the activity could just as well have been playing a sport, reading a book, or finding our way in a part of town we are unfamiliar with.

Motivation and Ability

People develop strategies to select information, including risk information, that they feel is relevant to them. In the technical literature, the general phenomenon is sometimes referred to as the "selection process." The major criteria for selection are ability and motivation (Chaiken and Stangor 1987). Ability refers to the physical possibility that the receiver can follow the message without distraction; motivation to the readiness and interest of the receiver to process the message.

Two conditions have to be met to satisfy the criterion of ability: the information has to be accessible; and the receiver must have time to process the information. Several factors influence the motivation of a receiver to process the information. The information content has to be relevant (referring to personal interests, salient values, or self-esteem), and it should trigger personal involvement (with the issue, the content, or the source). Both motivational factors are reinforced if the receiver has some prior knowledge or interest in the subject or is in need of new arguments to back up his/her point of view. (Clearly, these points are relevant to the design of risk communication activities. See Chapter VI.) If both criteria are met, the individual selects the information. However, to economize further on time, he or she is going to evaluate whether it is necessary to study the content of the information in detail or to make a fast judgment according to some salient cues in the message received. The first strategy refers to the central route of information processing, the second to the

peripheral route (Petty and Cacioppo 1986; Renn and Levine 1991). The central route is taken when the receiver is so highly motivated by the message that he or she studies each argument carefully. The peripheral route is taken when the receiver is less inclined to deal with each argument but forms an opinion or an attitude on the basis of simple cues and heuristics.

Medium and Format

One other matter that we have chosen to discuss as part of the initial filtering or selection process is the role of medium and format. As common sense suggests, any message aimed at a mass audience, including a message about risk, is more likely to be attended to if it arrives in an attractive and accessible "package." Everything else equal (level of distraction, motivation, ability), a boring package will be more likely to be filtered out than will an intriguing and attractive one. Thus, for example, a four- or five-page single-spaced letter is far less likely to be read than a much briefer one, perhaps accompanied by a colorful brochure. A radio spot might get more attention still. And a few minutes on TV, with action and not just words, might be most effective of all at getting attention. Commercial advertising agencies make a living by devising "best" ways to get attention and transfer at least modest amounts of information about products and services within constraints on budgets and on acceptable media, images, and vocabulary.

Now let us follow the information that has passed the initial filtering process and discuss subsequent reactions to it on the part of the individual. These reactions we are also calling filters, since they determine what part of the original message, if any, gets through to the information processing (cognitive) center. We consider three sorts of subsequent filters: those based on emotional reactions to the message or experience; those based on cognitive processing applied to peripheral features of the message rather than its content; and what we call mixed filters, which seem to display features of both emotional reaction and cognitive processes.

Emotional Filters

Within this category of information filters, we distinguish two major types: denial and "defensive passivity," and reaction to authority. Within each type, several variations on the main theme may be identified.

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Denial and Passivity

Denial may usefully be thought of as an admission of inability to cope. For example, we may deny overwhelming threats or seemingly all-pervasive risks, even though small (such as one might understandably believe lurk in the food we eat). But denial can itself take several different forms.

"Perish the Thought"—Denial of Unwanted Thoughts

Denial can refer to a blocking from awareness of certain threats; we simply do not think of them. If we have been warned about a threat we forget the warning. This is what we usually think of as constituting denial, and this conception has a certain basic intuitive believability (Freud 1966).

Commonplace evidence of this type of denial is presented to many of us on a monthly basis when our credit card bill arrives. We are incredulous as we suddenly remember the purchases we have made and have

conveniently "forgotten." Would we have so readily forgotten a promise of a $1,000 check due us at the end of the month? Thus, denial is a motivated blocking from awareness of unwanted thoughts.

"What, Me Worry?"—Denial of Unwanted Feelings

There are other, more paradoxical forms of denial. One may, for example, acknowledge that a very dangerous situation exists but not feel worried about it. In other words, the external situation is acknowledged, but the feelings aroused by this danger are blocked from our awareness. This can lead to a pernicious response to danger, because it may preclude feelings from acting as a spur to protective action despite receiving adequate warning from authorities regarding impending danger (Freud 1966; Fenichel 1945).

The enormous power of this psychological mechanism in denying danger is shown in people's responses to questions about the aftermath of a nuclear blast; most people respond that after the blast they would do what they could to help the injured.

A different sort of example of this type of denial, called isolation of emotion, is the husband whose wife requires serious surgery. In the days prior to surgery he is solicitous toward her and takes time off from work to be near her; but oddly enough, he feels very little. Only when the surgeon informs him after the operation that all has gone well does the husband experience a welling up of feelings, and only then does he realize how frightened he has been all along.

The Myth of Personal Immunity

A third type of denial is that of myth of personal immunity. This is a belief that, although a very real danger is acknowledged, the disaster will strike somewhere else. "The other guy" will suffer. It is almost a cliché that recent victims of disasters, when interviewed, say that "this is the kind of thing that always happens to someone else. You never think it's going to be you" (Wolfenstein 1957). The enormous power of this psychological mechanism in denying danger is shown in people's responses to questions about the aftermath of a nuclear blast; most people respond that after the blast they would do what they could to help the injured.
Under certain conditions, denial may be functional. When threats are remote, it would be very troublesome to become anguished about all possible disasters that could befall us. And when faced with threats about which one can do nothing, it perhaps makes sense to not get oneself worked up. But in other circumstances, the mechanism of denial may be extremely ineffective, even irrational, as a means of coping with risk. If the husband whose wife was undergoing surgery had allowed his denial to prevent him from taking appropriate action, what would the consequences have been? At the very least his wife would have felt abandoned in a moment of great need.

To cite another, more general, example of the irrational nature of denial, consider the unhelmeted motorcycle rider who places some ill-defined James Dean image of masculinity above his own physical safety as he ventures forth blithely onto the highway, protected only by his adolescent sense of invulnerability. By a circuitous logic, this behavior could be called rational (i.e., using reference to values, etc.), but to do so is to confuse the terms rational and understandable. The behavior is indeed understandable, but only by reference to the irrational elements of his makeup.

Inner Peace as False Security

Another aspect of denial is the tendency to equate internal feeling states and external

states. People during times of threat sometimes believe that if they are "good," everything will turn out all right. Similarly, we sometimes believe that if we remain calm inside, and do not get upset by a threatening situation, that outside events also will remain calm; and conversely, that feeling upset will only lead to external disaster (Wolfenstein 1957). It is as if we are trying to control the gods by controlling ourselves. Young children do not make a distinction between that which is internal and that which is external, and one suspects that this tendency operates in adults as well during times of danger.

The Spectacle Response

The early stages of an actual disaster can elicit what might be called a "spectacle response." Here not only is danger denied, but the danger acts as a magnet and actually draws people into dangerous situations. Examples are those who go to the shoreline during predicted times of seiche, or those who visit fires. What is at work here? Why are people drawn to such experiences? Perhaps it is the case that such occurrences are experienced by the individual as an opportunity to face and to master childhood fears. Evidence for this reasoning is that at these times there is often a sense of elation experienced, suggesting that some emotional burden has, at least temporarily, been lifted.

Passivity in the Face of Threat

Two neighborhood dogs circle each other menacingly. Suddenly there is a lunge, a frightening bit of thrashing about, and one of the dogs rolls on its back in a posture of total submission. Communicated to the victor is the message, "Yes, I know you are far stronger than I, and it is no use to struggle. My only hope then is to throw myself on your mercy, and hope you will spare my life." It is suggested here that this well-documented animal behavior has a counterpart in human response to threat. When faced with an overwhelming threat, the public may respond with what seems to be paradoxical passivity. Instead of taking protective action in their own self-interest, they may adopt a fatalistic attitude, saying, "It's all in God's hands now," or "You can't run from fate." In risk literature this is commonly referred to as an "external locus of control," a belief that the direction and outcome of one's life are determined by forces outside oneself.

Locus of control has traditionally been a helpful lens through which to observe risk response, but it obscures as well as illuminates. The passivity we are describing is not an ever-present personality factor but, rather, a threat-induced, temporary, regressive response whose psychological meaning is not self-evident and thus requires further analysis. It is argued here that the passivity described above is actually designed to serve a protective function, albeit irrational in its method. It represents the individual's desire under extreme threat to seek an early childhood dependency upon a protective, omnipotent power. And yet recognizing that this is not possible, the passivity also expresses to the superior force, like the defeated dog, "I offer you my throat, have mercy on me" (Fenichel 1945). Conversely, active attempts at fending off (defeating) the threat by taking active precautions may seem to the individual a form of aggressive pride that will only provoke greater retaliation by the gods.

This phenomenon, sketched in stark terms here, would hardly be expected to manifest itself in pure, undiluted form, at least in a

psychologically healthy population. But this mode of response phenomenon, like many of the others discussed in this section, may act as a subtle counterpoint theme to more observable, rational reactions to threat. In their very subtlety lies their power, for these processes operate just out of reach of awareness, out of rationality's reassuring grasp.

The Tendency to Remain in Familiar Surroundings Despite Danger

The desire to remain at home during times of threat may be an attempt to counteract an intense feeling of abandonment.

Different types of dangers require different kinds of responses to avoid harm. Certain natural hazards such as hurricanes or floods may necessitate leaving one's home temporarily, or even permanently, as the most effective safety procedure. But it is well known that many people are very reluctant to leave their homes, and they place their lives in great jeopardy by ignoring warnings to evacuate. Obviously, powerful psychological forces, which can overcome our reality-bounded tendency toward self-preservation, must be involved. There are three closely related forces at work here, as described below.

Counteracting Feelings of Abandonment. The desire to remain at home during times of threat may be an attempt to counteract an intense feeling of abandonment. As stated earlier, one's unspoken faith in a variety of protective sources may have been shattered by the disaster, and all that remains to provide comfort is that which is familiar. Our home and belongings are the physical embodiment of our lives: our values, beliefs, our history, and our relationships. And thus, the home, traditionally seen as a refuge from the world, takes on even greater emotional significance. To surround oneself with the immediate evidence of the meaning of one's life is a way of combating the crumbling sense of meaning brought on by disaster (Wolfenstein 1957).

Mastery through Observation. Under conditions of threat, the tendency to regress toward childlike thought processes may lead people to believe that staying at home and watching things will afford them protection. This is a manifestation of the primitive belief that danger can be controlled by watching it, and a feeling that if we keep an eye on an object, it cannot harm us (Wolfenstein 1957). As primitive and unrealistic as this may sound, it may be part of the foundation of the "scientific coping style" discussed later in Chapter VI. What we can know about and understand is, in a sense, tamed and mastered. And by being able to predict, we feel a sense of power, as if we had control over the phenomena observed. It also is clearly related to the "spectacle response."

Mastery through Repetition. But what of those who have survived terrible disaster and have seen their homes destroyed and their belongings lost? How can we understand the desire of many people to return and rebuild on the same location despite the continuing possibility of recurring danger? More than economic and material considerations seem to be involved in such decisions. What seems to underlie this behavior is an attempt to master the traumatic event by repetition. The person places himself in the same situation in an attempt to restore an equilibrium that was destroyed by the force of the disaster. He rebuilds, not in hopes of repeating the disaster, but in hopes of bringing about a positive outcome next time. By taking action and rebuilding, he is transforming a passively experienced trauma into an actively directed successful outcome. This psychological

tendency is related to our observation of children's games during wartime. These games consist of repetition of the very themes that terrify the child: assault by an overwhelmingly powerful enemy. In these games however, the outcome is always a heroic victory by the forces of goodness over the power of chaos (Waelder 1933).

These games enacted over and over again with the same positive outcome are really very serious business to the child, an attempt to restore inner peace and balance following a shattering experience. And so, too, the urge by disaster victims to return and rebuild may be folly from one point of view, but seen from a psychological perspective is compelled by the urge to restore the internal forces of order over the power of chaos.

As we shall see in the following subsection, the impact of expert advice and warnings from authorities on these powerful mechanisms of denial may be profound, though not always in the desired direction.

Reaction to Authority

Ideally, when the public is faced with risks, the desired response would be one based on an objective assessment of danger. As we have seen, however, the term "objective assessment of danger" is an oxymoron. Dangers are filtered through complex psychological processes (such as denial) that heavily influence perception, attitude, and action.

Can the public's lack of objectivity be effectively countered by clear warnings from authorities? Certainly this is possible to an extent. However, the same psychological forces that lead to denial can also render authorities Cassandra-like in their impotence or can turn the authorities into scapegoats whose advice is actively resisted.

The following is a brief description of the various forms that this phenomenon may take and the depth of feeling elicited.

"Why Hast Thou Forsaken Me?"—Feelings of Abandonment

If feelings of intense vulnerability are evoked in times of disaster, a deep sense of abandonment by authorities may be experienced. Authorities in this conception are thought of as parental figures who have failed to perform their crucial protective task. In its strongest form, this perceived abandonment could result in despair. But even at lesser levels of disaffection, warnings could be ignored because authorities are no longer seen as potent protectors (Rado 1942).

Authorities as Scapegoat

When faced with an overwhelming uncontrollable threat, all of the carefully constructed laws of cause and effect, right and wrong, by which we have governed our lives, may be threatened. Emile Durkheim coined the term "anomie" for this intense state of personal breakdown of social meaning, and demonstrated that it can lead to suicide (Giddens 1972). But the human spirit does not yield easily. To avoid this ultimate breakdown, that is, to maintain a crucial sense of order and justice in our universe when things are seemingly out of control, there is a tendency to blame someone. If a scapegoat can be identified, then the universe can still be seen as lawful and controllable. This scapegoat is often the very authority whose responsibility it is to issue warnings and outline precautions (Rado 1942).

Another way of thinking about this mode of response is to see that clear warnings of danger

may threaten the public's wish to deny the danger. Ironically, it is the warnings themselves that become the threat and require warding off. Warding off can take various forms, but a common one is angry skepticism directed at authorities. This neutralizes the threat posed by the warning.

"Try and Make Me"—Rebelliousness against Mandated Measures

In risk literature, it is often said that voluntary precautions recommended by authorities are seen as more acceptable by the public than are mandated measures. Usually, the American Spirit of individual autonomy is cited as the reason for this preference. From what has been said here, mandatory precautions may also stir up long-held, perhaps partially dormant, beliefs and feelings about authority and obedience and may elicit childish responses such as resentment and rebelliousness.

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As young children we learn to deal with the world partially through thousands of warnings we receive from our parents, warnings designed to ensure our safety: "Don't play in the street"; "Never play with matches"; "If I see you swing that bat indoors one more time..." For children, rules of safety are inextricably linked with rules of obedience. And it is this primitive association that is evoked in times of danger, when our more sophisticated, more adult coping skills are threatened. Reinforcing this regressive tendency is the fact that catastrophes are often perceived as punishment or, perhaps, as divine retribution.

Reliance on the Protection of Superior Authorities

During times of threat, there may be a tendency to rely passively on the power of authorities to protect one from danger. In effect, an external threat may act to shut down one's more mature tendencies to take self-protective action and may take one back to early feeling states when one felt safest if mother and father were interposed between us and danger.

Partial Compliance: Pacifying by Concession

As we have seen, in times of threat childhood themes of goodness, obedience, disobedience, and punishment reemerge. Another manifestation of this recurring theme is the tendency to comply with certain parts of recommended precautions while ignoring other, perhaps crucial, parts. What is at work here is an attempt to demonstrate one's moral goodness through superficial compliance. This "goodness" can then be used psychologically in one of two closely related ways: to exempt oneself from other tasks (like a child who tells himself he has been very good for quite some time and is therefore entitled to do as he pleases) or to support an underlying denial. In other words, isolated, circumscribed compliance may allow one to say in effect, "I've done almost everything you asked, and now I've earned the right to relax and forget about it" (Wolfenstein 1957).

Pleasing Authorities Rather Than Coping with the Threat

Partial compliance may spring from other causes as well, but with the same potential for harmful outcome. For example, the public may put recommended precautions into effect, but not for the purpose of protecting themselves from danger as much as to avoid censure from authorities. The motivation for carrying out protective measures would be immaterial but for the fact that this type of ambivalent compliance tends to be superficial

and halfhearted. To better appreciate the impact of this ambivalence, we have only to recall any recent directive from our supervisor to perform what we felt to be an unnecessary task. The task may have been completed, but certainly not with the same vigor as when we sincerely believe in a project.

Cognitive Filters

Before people get around to processing the risk information they have received, and not filtered out via emotional reaction to the threat depicted or to authority per se, they may still do some cognitive processing of the information *about the source* of that information and the relation between characteristics of that source and of the message received. This processing may proceed from what seem quite unnecessarily cynical assumptions of responsible agency officials, but we characterize it as cognitive because it seems to us to involve the application of logic rather than the following of feelings. We recognize the possibility of disagreement on this point. (Cognitive processing of the information itself is the subject of Chapter IV.)

As experience of risk has been replaced by information about risks, and individual control over risk by institutional risk management, trust in institutional performance has been the major key to risk responses. Trust in control institutions can lead to the implicit acceptance of even substantial perceived risk, while distrust may lead people to oppose actions that imply risks, even when those risks are perceived as small.

Trust can be substructured using the following five perceptual components (Barber 1983; Lee 1986; Renn and Levine 1991):

- Competence (degree of technical expertise in meeting institutional mandate)
- Objectivity (lack of biases in information and performance as perceived by others)
- Fairness (acknowledgment and adequate representation of all relevant points of view)
- Consistency (predictability of arguments and behavior based on past experience and previous communication efforts)
- Sincerity (honesty and openness)

Trust relies on all five components, but poor marks on one attribute may be compensated by an excellent reputation or excellent performance in another dimension. For example, if objectivity or disinterestedness is impossible to accomplish, apparent fairness of the message and faith in the good intention of the source may serve as partial substitutes. Consistency is not always essential in gaining trust, but persistent inconsistencies destroy the common expectations and role models for behavioral responses. Trust cannot evolve if people experience inconsistent responses from others in identical or even roughly similar situations.

All public institutions have lost trust and credibility over the last few decades except for the news media (Lipset and Schneider 1983). Trust and credibility losses are high for the political system and many government agencies. Science still has a high degree of credibility, although much less than two decades ago. Since many risk managing agencies have been caught in the maelstrom of distrust, it is essential to revive the major elements of trust through performance and communication.

Trust in control institutions can lead to the implicit acceptance of even substantial perceived risk, while distrust may lead people to oppose actions that imply risks, even when those risks are perceived as small.

Research shows clearly that there is widespread agreement in the public as to what figures are culturally defined as more or less trustworthy (McGuire 1985; Stern and Aronson 1984). For example, when considering information presented concerning technological risks, it was the university scientist who was seen as far and away the most reliable of sources, because he or she was perceived as the disinterested scholar, uncontaminated by the desire for gain, committed to truth, and highly qualified in knowledge and assessment skills. Contrary to that, the industry representative was seen as the least reliable source of information concerning technological risk. And for the flip side of the reasons already cited: such persons are perceived as biased in interest, selfishly motivated, willing to dissemble, and without the expertise necessary for competent risk assessment. Clearly, the choice of spokesperson, the personification of any attempt at risk communication, is one of major importance.

Low-probability high-consequence risks are usually perceived as more threatening than more probable risks with low or medium consequences.

Mixed Filters

Some varieties of information filtration processes appear to combine elements of pure emotion and of cognition (more or less logical thinking). We identify and single out for brief discussion three such processes:

- Taking account of auxiliary dimensions of a risk
- Attempting to resolve cognitive dissonance
- Responding to the "framing" of the message rather than to the quantitative information it contains

Responding to Auxiliary Characteristics in Judging Risks

The type of risk involved and its situational characteristics shape individual risk estimations and evaluations (Slovic 1987; Renn 1990). Statistical methods have been employed to explore these qualitative characteristics of risks. (See also the discussion in Chapter IV.) The following contextual variables of risk have been found to affect the perceived seriousness of risks (Slovic et al. 1981; Vlek and Stallen 1981; Renn 1983; Covello 1983; Gould et al. 1988):

- ***The expected number of fatalities or losses.*** Although the perceived average number of fatalities correlates with the perceived riskiness of a technology or activity, the relationship is weak and generally explains less than 20 percent of the observed variance. The major disagreement between technical risk analysis and risk perception is not on the number of affected persons but on the importance of this information for evaluating the seriousness of risk.

- ***The catastrophic potential.*** Most people show distinctive preferences among choices with identical expected values (average risk). Low-probability high-consequence risks are usually perceived as more threatening than more probable risks with low or medium consequences.

- ***Situational characteristics.*** Surveys and experiments have revealed that perception of risk is influenced by a series of perceived properties of the risk source or the risk situation. Among the most influential factors are the perception of dread with respect to the possible consequences, the

conviction of having personal control over the magnitude or probability of the risk, the familiarity with the risk, the perception of equitable sharing of both benefits and risks, and the potential to blame a person or institution responsible for the creation of a risky situation. In addition, equity issues play a major role in risk perception. The more risks are seen as unfair for the exposed population, the more they are judged as severe and unacceptable (Kasperson and Kasperson 1983; Short 1984).

- ***The beliefs associated with the cause of risk.*** The perception of risk is often part of an attitude that a person holds about the cause of the risk, that is, a technology, human activity, or natural event. Attitudes encompass a series of beliefs about the nature, consequences, history, and justifiability of a risk cause (Thomas et al. 1980; Otway and Thomas 1982). Due to the tendency to avoid cognitive dissonance (as discussed below), most people are inclined to perceive risks as more serious and threatening if their other beliefs contain negative connotations and vice versa. A person who believes that industry policies are guided entirely by greed is likely to think that the known risks of industrial pollution are only the "tip of an iceberg." On the other hand, a person who thinks of industry as providing consumers with goods and services they need and value may well be inclined to think that concern about such pollution is overblown.

Resolving Cognitive Dissonance

"Cognitive dissonance" (Festinger 1957) is a term that describes the individual's reaction to simultaneously holding two incompatible points of view. Such a state of internal discord causes great tension, which forces rapid resolution, most often in the form of deleting or modifying points of view until internal consistency is achieved. Consider, for example, the long-time employee of corporation X, who is informed that the firm is behaving in a way that threatens life (dumping toxic materials where it can leach into the groundwater used by the town for its water supply or storing water behind an unstable rubble dam or allowing a lung-destroying dust to accumulate to dangerous levels in the workplace). Our hypothetical employee almost certainly has some stake in believing the organization she has devoted her life to is good. But she also has a stake in self and community preservation. For that purpose our hypothetical person would have to accept that the firm is causing danger, is not being "good." Something will have to give, and depending on the circumstances it may be either belief in the firm or belief in the danger.

Response to "Framing" of the Risk

"Framing" problems arise when the words used to describe alternatives under uncertainty are changed—*without changing the substance of the choice*—and produce a change in the preferred alternative. A classic example goes as follows (Kahneman and Tversky 1982).

> *Imagine that the U.S. is preparing for the outbreak of a rare Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the scientific estimates of the consequences of the programs are as follows: If Program A is adopted, 200 people will be saved. If Program B is adopted, there is a 1/3 probability that 600 people will be saved and a 2/3 probability that no people will be saved. Which of the two programs would you favor?*

The majority response to this problem is a risk-averse preference for Program A over Program B.

Other respondents were presented with the same problem but a different formulation of the programs: If Program C is adopted, 400 people will die. If Program D is adopted, there is a 1/3 probability that nobody will die and a 2/3 probability that 600 people will die.

The majority choice in this problem is risk-seeking: D over C. The certain death of 400 people is less acceptable than a 2/3 chance that 600 people will die. (pp. 166-67)

Since A and C are mathematically identical, as are B and D, the observed differences in choices exhibited in these experiments means that we are not dealing here with purely rational thought. Clearly, the choices are at least in part emotional responses to the different pictures conjured up by "deaths" and "lives saved." In the first version, the reference point or status quo is implicitly 600 deaths, while in the second framing, the reference point becomes zero deaths. Thus, in one case respondents are thought to be evaluating "gains" and in the other "losses." But again, the fundamentals of the given problem are explicitly *gains*, because we are told that in the absence of any intervention, 600 lives will be lost. The two interventions both improve on that base case, at least in expected value terms.[4]

Conclusions

When the process of taking in information about risks is presented, with the stress on multiple "layers" of filtration, what is perhaps remarkable is that we learn anything at all, not that some of what we think we have learned is less than useful. But this is an extreme, pessimistic interpretation. Much of what has been said above applies only to times of great stress and even then probably only applies to a small fraction of the population involved. This is true, for example, of most of the denial responses. However, we do have to take seriously the observations about the importance of making risk communication clearly relevant to the audience; of choosing an accessible medium and an attractive format; of not coming on with a parental, authoritarian message; of working to protect competence, objectivity, fairness, consistency, and sincerity; and of being sensitive to subtleties of framing (describing) the risk and the decisions.

We shall return to these and other related matters in Chapter VI. But in the next chapter, we turn to a discussion of the cognitive problems individuals display when they come to operate on and make decisions on the basis of the filtered information available from the outside world.

[4] Kahneman and Tversky attribute the result to the S-shaped utility (outcome-weighting) function, which implies risk seeking for loss gambles and risk aversion for gain gambles. (See Chapter IV.) But there is also considerable similarity between this sort of "framing" problem and the reaction of subjects to the Allais paradox gambles, also discussed in Chapter IV. Both seem to involve unacknowledged, and in a logical sense unjustified, shifts in the assumed status quo.

Chapter IV

Cognitive Problems with Risky Decisions

In principle, by suitable design of laboratory experiments or by careful interpretation of data from natural experiments, it should be possible to probe the following three cognitive aspects of how nonexpert individuals deal with decision making under uncertainty:

- How they define, estimate, and manipulate probabilities. (Recall that subjective probabilities are generally accepted as part of rational decision making.)

- How they interpret, and especially, how they weight the possible outcomes in an uncertain situation. (Recall that subjective "utility" weights are also an accepted part of rational decision making.)

- What sorts of decisions they make when confronted with actual choice situations, whether in or out of the laboratory.

Indeed, understanding the cognitive limitations of individuals' use of the normative, rational model of choice under uncertainty has been developing for at least thirty-five years, though examples illustrating those limitations have existed since the eighteenth century. The size and richness of the literature in this field poses its own problems—how to do it justice; how to make connections among at least a few of its many dimensions; how to reconcile some of its apparent contradictions; and how to draw from it practical lessons for planners and decision makers in the Corps of Engineers. The approach taken in this chapter will be to use the structure of the rational model to organize a catalog of phenomena that have troubled thinkers in this field and to discuss:

- The relation among the phenomena

- The existence of occasionally contradictory findings

- The extent to which the "problems" may represent entirely rational adaptations to the complexity and conflicting signals of the real world (as opposed to evidence of true limitations on the rationality of human beings)

The drawing of lessons will be postponed to Chapter VI of this guidebook.

Problems with Probabilities

In the rational model, individuals are supposed to either draw their probability information from objective facts (such as the shapes of coins or dice; or records of events such as rainfall), or they are supposed to construct their own probabilities from their subjective judgments (such as one might do by looking at the sky in the morning and judging how likely rain is that day). In either case, for any but the simplest situations, these same individuals should manipulate the

probabilities in ways that are consistent with some of the fundamental rules of probability theory.[5]

Understanding Independence of Events

In the last chapter, we saw that some individuals do not appear to be able to understand the independence of events. An example almost everyone will have experienced, either in themselves or others, is a disinclination to take the independence of events seriously. Thus, people are inclined to attribute memories to dice and coins as an outgrowth of a misunderstood version of the law of large numbers. (Some individuals will argue vigorously that tails *must* be more likely after heads has come up five or six times in a row.) Analogously, people often seek comfort or certainty by attributing weather events such as floods and tornadoes to some sort of extraworldly intelligence or to a cyclical process (Kates 1962; White 1964). The general effect of such beliefs is to lower the subjective probabilities people hold for events that have just happened or for events that have happened frequently relative to some notion of the long-run mean occurrence rate. Operationally, the most important manifestation of this is probably the belief, often widely shared within groups that have experienced a natural disaster such as a serious flood, that a repeat performance "can't" occur for a long time.

...people are inclined to attribute memories to dice and coins...

Incorporating New Information

Another major *technical* error that has been observed in handling probabilities is with updating in the face of new information. Rational individuals who use subjective probabilities should also use Bayes' theorem to update those probabilities when they are given relevant new information.

Updating subjective prior probabilities (or for that matter, objective prior probabilities) using Bayes' theorem can be illustrated with an example based on one in Parzen (1960) on page 119. Assume a district engineer's initial subjective probability is 0.005 that a particular dam is likely to fail in a given ten-year period. This estimate would be based on engineering judgment and what is known about the dam's site; construction quality; history of overtopping, erosion, and leaks; and other relevant features and/or knowledge of failures of other similar dams. Further, suppose that we have available a test that correctly predicts an imminent failure (failure within ten years), when conditions are right for that, 95 percent of the time. The test also correctly gives a dam that has no chance of failing within a decade a clean bill of health 95 percent of the times it is used in that situation. Finally, suppose the hypothetical dam is tested and the prediction is for failure within ten years. What should be the engineer's new estimate of the probability that the dam will fail? Bayes' theorem says that the new probability should be:

> *The prior failure probability times the probability of a positive test given conditions for failure (0.005 x 0.95) divided by the sum: The probability of a positive test given the conditions for failure times the prior subjective probability of failure plus the probability of a positive test given that the conditions for failure do not exist times the prior probability of no failure (0.95 x 0.005 + 0.05 x 0.995). So the new failure probability should be: 0.00475 ÷ 0.0545 = 0.087.*

[5] Recall, we are talking here about the normative theory. People *ought* to behave as though they did these things. That this is not at all the same as a theory purporting to explain how they *do* make decisions is the purport of this guidebook.

Observe that the test result should cause the engineer to revise his or her initial probability estimate all the way from 0.005 to 0.087, a multiple of over 17.

There are at least two problems with lay (and even expert) behavior vis-à-vis this prescription. First, Bayes' theorem is simply not well known, and even those who have heard of it, and possibly even used it in a statistics class, are unlikely to have developed any true familiarity with its operation. Second, its results appear to be counterintuitive in many situations. The reader may find this true for the example sketched above, where the prior probability estimate is very low and the ability of the test to detect the condition at issue is very high. Thus, in the above example, many lay observers and every professional one might be tempted to say that if such a "good" test gave a warning of failure, we "ought" to take it more seriously and revise the probability of failure to something closer to 0.95. This might be called a tendency to overweight "diagnostic" information, relative to previously held notions.[6]

Finally, it should be noted that Smith and his collaborators have found, in a study of the communication of radon risk, that individuals did process skillfully provided information as though they were at least approximate Bayesians (Smith et al. 1990).

Estimating Subjective Probabilities

Whether people at large can or cannot manipulate probabilities, it does not seem that they are very good at estimating them in the first place (Fischhoff 1988; and Lichtenstein et al. 1982). Kahneman, Tversky, and others have discovered that individuals without special training or expertise tend to overestimate the probabilities of very rare events (such as deaths by exotic causes) and underestimate the probabilities of more common events (Slovic et al. 1982). Even where outside information on probabilities is available, individuals will tend to supply their own subjective version in which low-probability events are treated as though more probable, and higher-probability events as less probable than the information supplied would indicate (Kahneman and Tversky 1982). This is shown schematically in Figure IV-1. Here "decision weights" may be thought of as subjective probabilities supplied by the experimental subjects, while "probability" refers to objective likelihood estimates for the same phenomena. If the experimental subjects were perfect judges of probabilities, the "decision weight" line would coincide with the 45° line. That is, the estimated decision weights would equal the objective probability estimates.

It is not clear whether this phenomenon arises from a fundamental difficulty in coming to grips with numbers such as 10^{-6}, or because very rare events are brought to our attention only when they happen, while more common events bask in relative obscurity. (On research into the difference between subjective probability estimates and "true" probabilities, see Lichtenstein et al. 1982). What is clear is that if we have reason to doubt people's ability to get the magnitude of probabilities right, then it is very hard to work backward from observed decisions to infer the implied weighting pattern for outcomes. This is a

[6] Another way of thinking about the intuition that the new probability—that reflecting the results of the test—ought to be 0.95 is as a rejection of the original probability. If, for example, that original estimate had been 50/50 for the fail/do not fail chances, 0.95 *would* be the appropriate post-test probability. But even if the original failure probability had been 0.25, the appropriate post-test probability would be 0.864, nearly as large as the test's ability successfully to identify a dam about to fail.

subject we take up in the next subsection.

From the point of view of the Corps of Engineers, the problems arising from this tendency might be of several sorts. For example, the chances of negative consequences from very rare events involving failure of Corps facilities, such as levee overtopping, may be generally overestimated by the public. On the other hand, in thinking about the design of a new facility, that same public may be unhappy about local participation in the cost of protection against relatively common occurrences (ice damage to structures in northern rivers). All these considerations suggest that providing the public with good information about probabilities of events of concern in particular planning and decision situations has to be a fundamental part of Corps efforts.

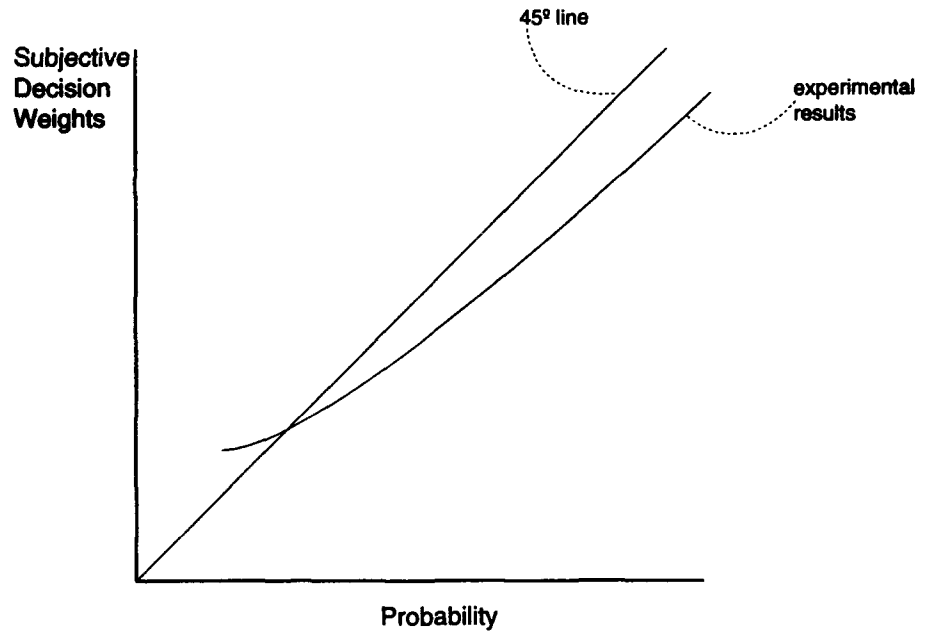
...providing the public with good information about probabilities of events of concern...has to be a fundamental part of Corps efforts.

The Dominance of Sensational Information

But even this general exhortation makes it necessary to mention a couple of other phenomena that are sometimes discussed as features of a "probability problem" but may be interpreted in other ways as well. In particular, the tendency of laymen to fasten onto the sensational may not be part of a cognitive problem. Sensational information is, almost by definition, very available information. For most purposes in most activities of most ordinary lives, it is not worthwhile for individuals to spend scarce time or money in seeking out information on which to base a probability estimate. If something pops up,

Figure IV-1

Decision Weights Related to Probabilities



Source: Kahneman and Tversky 1982

ready to hand, it may well make sense to use it. If this makes us overestimate the probability of being murdered by devil-worshipping cultists, it is probably not a problem for anyone. But if it makes many people overestimate the chances of overtopping of a levee, then we do have a collective problem.

The Role of Expert Judgments

In the matter of expert judgment and its role in subjective probability formation, we have to keep in mind that citizens of modern, free democracies hear constantly from experts who disagree about everything under the sun: whether a little drinking is good for you or not; whether paper or Styrofoam cups are easier on the environment; whether an interest rate cut by the Federal Reserve Board is currently desirable; whether we should try to introduce a greater element of parental choice into public education. What has to be clear to the observer of this cacophony is that, for every issue, one of the sets of contesting experts is wrong. The trick is knowing who they are in advance. In the absence of costly (in time and money) investigations of who is most likely to be right in any given situation, rules of thumb such as "split the difference" or "a plague on all their houses" can certainly not be ruled irrational.

Problems with Weighting Outcomes in Uncertain Situations

In Chapter II, we discussed the possibility that in some situations, particularly those involving widely dispersed uncertain outcomes, individuals may rationally want to apply nonlinear weighting schemes to the outcomes in addition to taking account of probabilities. For example, if the design decision at issue involves a flood control problem, any particular design alternative may produce a very wide dispersion of flood damages avoided compared to the no-project case. Thus, one quite improbable event involving x inches of rain in 24 hours, which would have caused huge losses before the project, might successfully be controlled, implying equally huge benefits. But an event of only slightly lower probability and slightly higher rainfall might overtop all the planned defenses and cause about the same damages as in the without project situation, i.e., might imply zero benefits (damages avoided). In such a situation, the decision maker(s) might well think that another dollar of benefits added by a project refinement when benefits are already high (perhaps involving investment in recreational facilities) is worth less than another dollar of damage prevention in the overtopping case (perhaps simply by an increase in emergency spillway capacity).

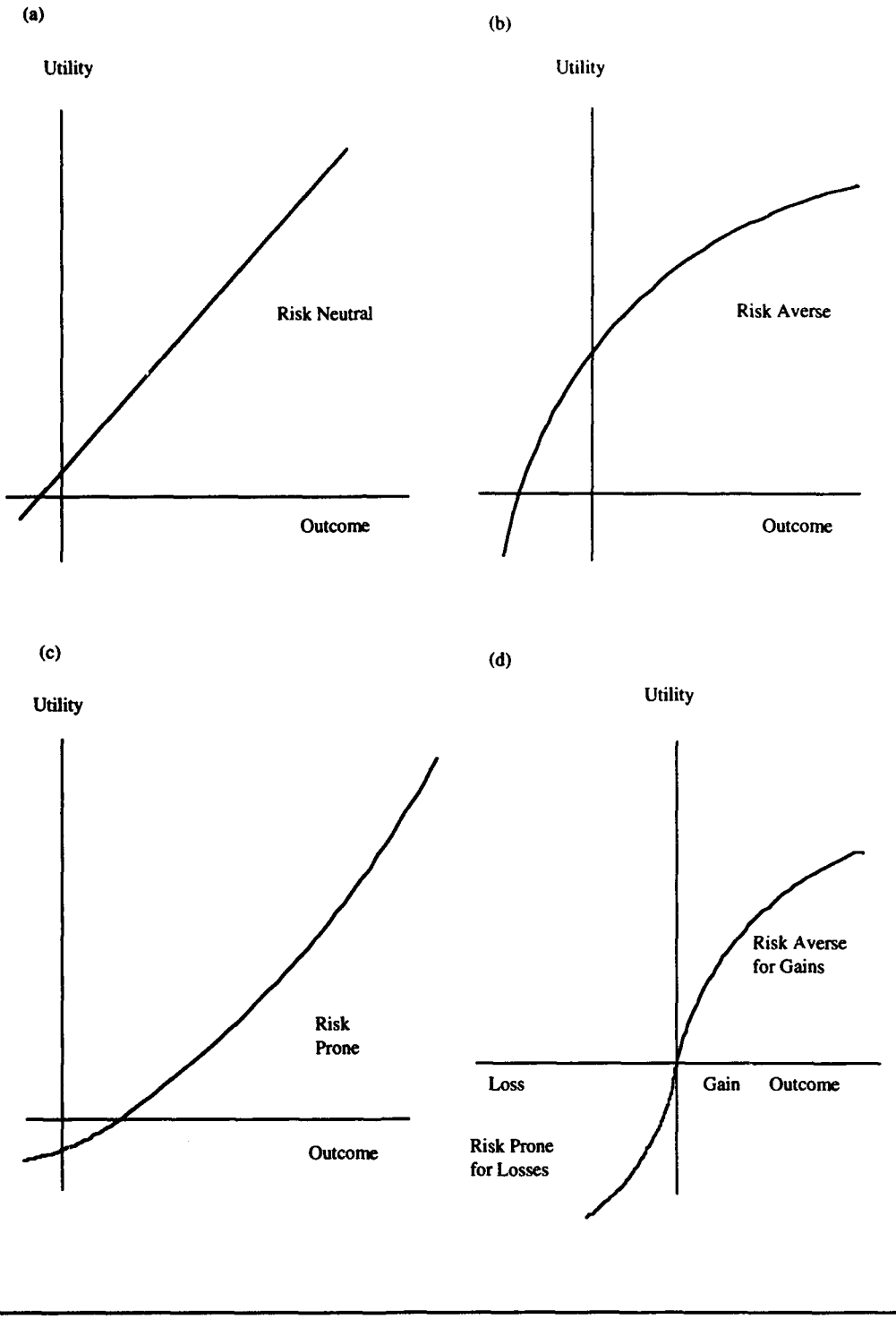
Utility Functions

Economists usually refer to weighting functions as "utility" functions, and we may distinguish between functions (or weighting schemes) that reflect aversion to "risk" and those that reflect a positive seeking out of "risk." Here "risk" may be thought of as the dispersion of outcomes (e.g., their variance or standard deviation.)

Risk aversion is equivalent to the feeling described above that the "value" of another dollar of benefits is smaller, the higher the benefits are—the value of losses is larger, the larger the losses (see Figure IV-2). It is important to understand that these functions of whatever shape need not remain academic abstractions. It has been demonstrated in practical decision problems that it is possible through skillful questioning to construct such

Figure IV-2

Utility Function Shapes and Their Characterization



a weighting function for an individual over the range of outcomes faced in the decision to be made (Benjamin and Cornell 1970).

Other than our expectation that anything called "utility" ought to increase as the underlying outcomes improve, however, we cannot judge the "correctness" of patterns displayed in actual situations by lay or expert individuals. But it is usually hypothesized that most people in most situations in their daily lives are risk averse. This pattern of utility weight is consistent with the purchase of insurance at a premium exceeding the expected value of the loss from the insured-against event. It is not consistent with purchasing lottery tickets at prices above the expected value of the winnings. That behavior bespeaks risk-seeking preferences.

Evidence about Utility Functions

There is, however, some evidence (Kahneman and Tversky 1982) that, at least in laboratory settings, individuals use utility-weighting schemes that are risk averse for gains and risk seeking for losses, certainly an odd, though not an irrational, pattern. If this pattern were widespread, we would commonly not see insurance purchased against catastrophic losses, but neither would we see much activity in the lottery (or numbers) business. Thus, the fact that we do see lines outside of stores selling state lottery tickets when the prizes become very large, and that we see people buying at least some kind of insurance suggests that the laboratory results may not be terribly good guides to reality. Admittedly, the insurance purchases are generally required as conditions for obtaining a mortgage or registering a car. Newer forms of insurance, often not required, such as flood insurance do seem to be widely neglected by consumers (Kunreuther and Slovic 1978).

Observe also, that in trying to infer subjective weighting schemes from actions, we run into an identification problem of sorts. If we believe that individuals take any account of both outcomes and (subjective) probabilities, we cannot disentangle the "cause" of observed decisions. For example, an individual could have risk averse preferences but still buy lottery tickets if that individual systematically overestimated the chance of winning the grand prize. (And such systematic overestimation is what "feeling lucky" is all about.)

Problems with Observed Judgments in Risky Situations

The last subsection referred to certain patterns of decision that have been observed in the debate about cognitive limits on individuals' ability to deal with uncertainty. These patterns include the purchase of insurance at premiums exceeding the expected value of the losses and the purchase of lottery tickets at prices above the expected value of the winnings. It was pointed out that such actions are not evidence of inability to cope with risk. It is almost always difficult to say, outside a laboratory setting, what they are evidence of, since subjective weights and probability estimates may reasonably be thought to interact in the decision process.

Within laboratory settings researchers can better control the information and incentives that lie behind decisions under risk. And in such settings, or in closely related survey research, there is evidence of actual logical failures in individuals' risk-related decision

processes. We shall consider three kinds of problems that research has discovered:

- The paradoxes, exemplified by the "Allais paradox" in which revealed decisions violate a fundamental axiom of the rational model

- "Preference reversal" in which stated preferences over generalized "lottery tickets" (explained below) contradict the relative prices for which the subjects would be willing to sell the same "tickets"

- "Risk ratings" in which subjective ratings of activities, both individual and collective, have been shown to be highly imperfectly related to the actual risk of death posed by the activities[7]

The Allais Paradox

The "Allais paradox" involves a combination of logic and empiricism demonstrating that individuals faced with uncertain, lottery-type decisions, violate what is known as the "independence axiom." That is, when individuals choose between two lotteries (mixes of probabilities and outcomes) they do not focus only on the differences but also take account of the similarities. The following way of visualizing the paradox is attributed to Robin Dawes (Pool 1981). Imagine an urn filled with 100 balls, divided as follows: 89 red balls, 10 blue balls, and 1 black ball. Now imagine that four different games of chance (referred to here as "lotteries") have been created based on this urn. In each lottery, the payoff obtained by the player is determined by which color ball is drawn from the urn. In the experiments, the subjects are each asked to make two choices: between lotteries A and B and between C and D, where the payoffs for each lottery are as described in Table IV-1.

Logically, the only difference between the two choices is the result of drawing a red ball. In both A and B a red ball gets you a million dollars; in both C and D it gets you nothing. Therefore, the independence axiom requires that someone who prefers A to B also prefers C to D and vice versa. But empirically there is a very widespread, if not unanimous, choice of A over B and D over C.

Table IV-1

Payoff Matrix

	Outcomes			
Ball Drawn	A vs. B		C vs. D	
Red	$\$10^6$	$\$10^6$	0	0
Blue	$\$10^6$	$\$2.5 \times 10^6$	$\$10^6$	$\$2.5 \times 10^6$
Black	$\$10^6$	0	$\$10^6$	0

[7] "Framing problems" that crop up in this same literature have been classified in this guidebook as part of the filtration process and were discussed in Chapter III.

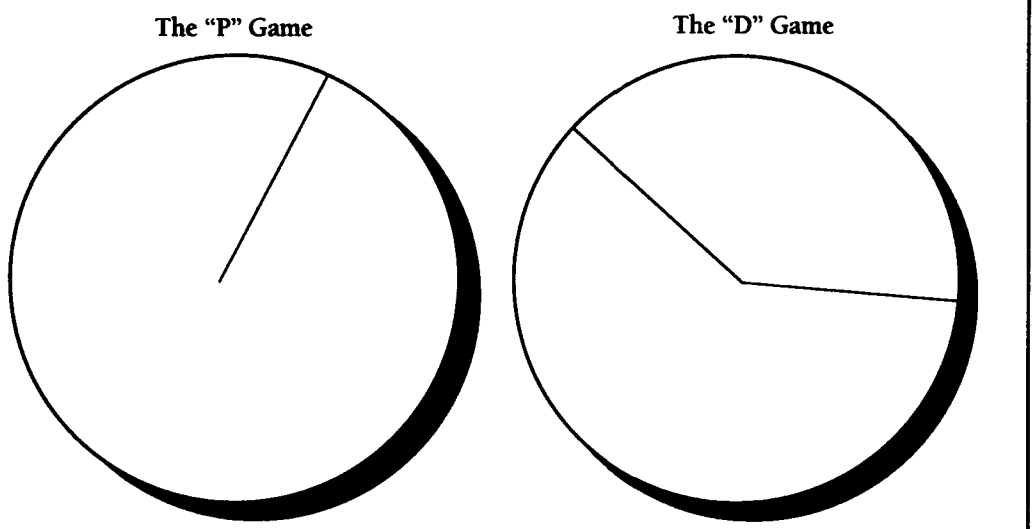
One can tell stories that explain this behavior, such as invoking the notion that the prospect of the certain $1 million in A produces a new status quo. Then, the choice between A and B is interpreted as a choice between a 10/11 probability of adding $1.5 million and a 1/11 probability of "losing" the $1 million that is notionally in hand. In the C vs. D choice there is no change in status quo accepted implicitly, so the (unlikely) zero event is not translated into a loss. But story or no story, the real situation does not involve a change in the status quo, and the commonly observed choices are irrational. They bespeak problems with handling choice under uncertainly that go beyond difficulties with probabilities and odd subjective utility patterns.

Preference Reversal

"Preference reversal" is said to occur when contradictory answers are given to two different questions concerning choices among a single set of alternative "lottery tickets." Again, a classic example should help make clear how the reversal arises and what it means. Grether and Plott (1979) provide a simple graphic one in their important paper on this phenomenon.[8]

Figure IV-3

Dart Board Patterns for the Preference Reversal Experiment



[8] Grether and Plott also report on the rather large psychology literature—even up to that date—that had explored this phenomenon.

Imagine that you can choose between playing two games, P and D, with darts (see Figure IV-3). In P, the dart board is a circle with a single radial line. A dart is thrown by a blindfolded person (with nonetheless a guarantee that it will hit the interior of the circle). If it hits on the radial line, you will receive nothing. If it hits anywhere else, you will receive $4. (Clearly this is a near certain $4.) The alternative board, D, is divided into two areas by a pair of radial lines. One area, covering say 40 percent of the circle, will produce a $16 payoff if the dart hits it. The 60 percent area produces a zero payoff if hit.

The subjects who are presented with these two games are asked to say which one they would prefer to play and to assign a money value to each, usually thought of as the price for which they would sell the right to play the game if they held it. Consistently over actual experiments, a large proportion of those presented such problems say they ***prefer*** *the P game but assign a higher value to the D game.*

As in the previous two examples, we see a clear problem with the logic (or rather the illogic) that must lie behind this contradiction. It comes down to this. If you *prefer* P to D you ought to require being paid a higher price to give up P if you owned the right to play it than you would require to give up D if you owned the right to play it.

Grether and Plott, in their own preference reversal experiments, worked very hard to eliminate any conditions that might allow the reversal phenomenon to be argued away as rational (e.g., they tried to make the gamble payoffs large enough so that they could assert that serious efforts were being made by the experimental subjects to make correct judgments. They also designed the pattern of payoffs so that increasing wealth as the experiment proceeded would not be a potentially distorting factor.) Further, they attempted to control for a set of competing noneconomic theories of decision making under risk with the aim of ruling out as many of these as possible. In this latter regard they could not in the end rule out one possibility related to a previously discussed problem, the effect of framing. That is, they could not rule out the possibility that decision makers seize on "anchoring" information such as probabilities in one case and payoffs in another for reasons that have little to do with the quantitative substance of the gambles in question, but more to do with the language and context of the experiment (or real decision). If true, it becomes very difficult to understand in any general way what people think they are doing when they make uncertain choices. Even more disturbing is the prospect that once some understanding was developed, manipulation would, in principle, become extremely easy.

There is, however, another side to the literature on preference reversal, albeit a strain that remains to date obscure because unpublished. The principal source of this other side is Peter Bohm at Stockholm University, and his contribution has been to move the experimentation out of the laboratory and to increase by a factor of several hundred the significance of the payoffs involved in the P and D games. In Bohm's first experiment, the P and D "lotteries" were defined by used cars. The subjects were university graduate students who were in the market for a car. From the subjects who chose to participate, Bohm extracted rankings of the cars as well as stated willingness-to-sell prices. He found no preference reversals (Bohm 1990). In another nonlaboratory experiment,

this one involving real-world lottery tickets, Bohm and a collaborator found that 11 percent of the subjects exhibited preference reversal, a considerably smaller percent than has been found in the laboratory exercises (Bohm and Lind 1991). This suggests that the laboratory results may actually include an element of minimizing decision costs in the face of rather trivial rewards despite the efforts of experimenters. This, in turn, suggests we should be doing additional research before using preference reversal evidence as part of an argument for the widespread existence of serious cognitive problems in individuals' ability to deal with uncertainty.

Estimates of Relative Riskiness

Estimates of "relative riskiness" of individual and collective activities have been of considerable interest since people began pointing out that individuals regularly pursue voluntary activities that are much riskier to themselves than are the collective activities they often object to on the grounds of riskiness (Starr 1969). Viewed as an apparent disconnection between acceptable, self-imposed, and what we call collectively suffered risk, this phenomenon seems to hint at another bit of evidence of cognitive difficulty in dealing with risk, for it shouldn't make any difference how the one-in-one-thousand chance of dying comes about. It might be argued that this phenomenon is a sort of large-scale Allais paradox, where the independence axiom is violated by otherwise presumably rational people.

Whether one is willing to go that far or not, it has certainly been the case that studies comparing the riskiness perceptions of lay people and experts have turned up substantial differences.[9] In general, lay people tend to underestimate the riskiness of such very risky activities as smoking, drinking, and driving, while they overestimate the riskiness of such exotic activities as mountain climbing and common "threats" such as vaccinations (Slovic et al. 1980).

It appears from the literature that has grown from this subject that the key to understanding the observations is the notion that far from being cognitively limited (though they may be *information* limited), lay people strive to work with a very complicated model when they decide what risks to be concerned about. Lay people think about a number of dimensions of the decisions or activities they are asked about (Slovic et al. 1980). For example, one study asked lay people to say how concerned they were about 90 different activities and then to rank the 90 activities or sources of risk (threats to lives) along eighteen dimensions as summarized in Table IV-2. Subsequent statistical analysis led the researchers to conclude that the eighteen dimensions could have been represented by three factors that determine the level of concern about (the perceived riskiness of) an activity. The first of these they labeled "dread," for it reflects such considerations as whether the activity is controllable, whether it could be globally catastrophic, whether its effects would persist in the future, and whether exposure is voluntary or involuntary. The second they label, "familiarity," and it reflects such considerations as whether or not the activity is observable, known to the exposed persons, known to science, and produces immediate effects. The third factor measures extent of exposed population. The sorts of results they obtained are shown schematically in Figure IV-4. Activities that score high on factor 1 (to

...individuals regularly pursue voluntary activities that are much riskier to themselves than are the collective activities they often object to on the grounds of riskiness.

[9] Riskiness is usually expressed in terms of deaths—numbers of deaths per year in the U.S. population caused by, or probability of a randomly chosen individual's dying from,

Table IV-2

Elements of a Survey of Risk Perception

A. The Hazards Ranked:

1. Home gas furnaces
2. Home appliances
3. Home power tools
4. Microwave ovens
5. Power mower
6. Handguns
7. Terrorism
8. Crime
9. Nerve gas
10. Nuclear weapons
11. National defense
12. Warfare
13. Bicycles
14. Motorcycles
15. Motor vehicles
16. Railroad
17. General aviation
18. SST
19. Jumbo jets
20. Commercial aviation
21. Anesthetics
22. Vaccinations
23. Pregnancy, birth
24. Open-heart surgery
25. Surgery
26. Radiation therapy
27. Diagnostic X-rays
28. Alcoholic beverages
29. Caffeine
30. Water fluoridation
31. Food coloring
32. Saccharin
33. Sodium nitrate
34. Food preservatives
35. Food irradiation
36. Earth orbit satellite
37. Space exploration
38. Lasers
39. Asbestos
40. Police work
41. Firefighting
42. Christmas tree lights
43. Cosmetics
44. Fluorescent lights
45. Hair dyes
46. Chemical disinfectants
47. DNA research
48. Liquid natural gas
49. Smoking
50. Tractors
51. Chemical fertilizers
52. Herbicides
53. DDT
54. Pesticides
55. Aspirin
56. Marijuana
57. Heroin
58. Laetrile
59. Amphetamines
60. Barbiturates
61. Darvon
62. Morphine
63. Oral contraceptives
64. Valium
65. Antibiotics
66. Prescription drugs
67. Boxing
68. Downhill skiing
69. Fireworks
70. Football
71. Hunting
72. Jogging
73. Mountain climbing
74. Mushroom hunting
75. Recreational boating
76. Roller coasters
77. Scuba diving
78. Skateboards
79. Sunbathing
80. Surfing
81. Swimming pools
82. Fossil electric power
83. Hydroelectric power
84. Solar electric power
85. Nonnuclear power
86. Nuclear power
87. Dynamite
88. Skyscrapers
89. Bridges
90. Dams

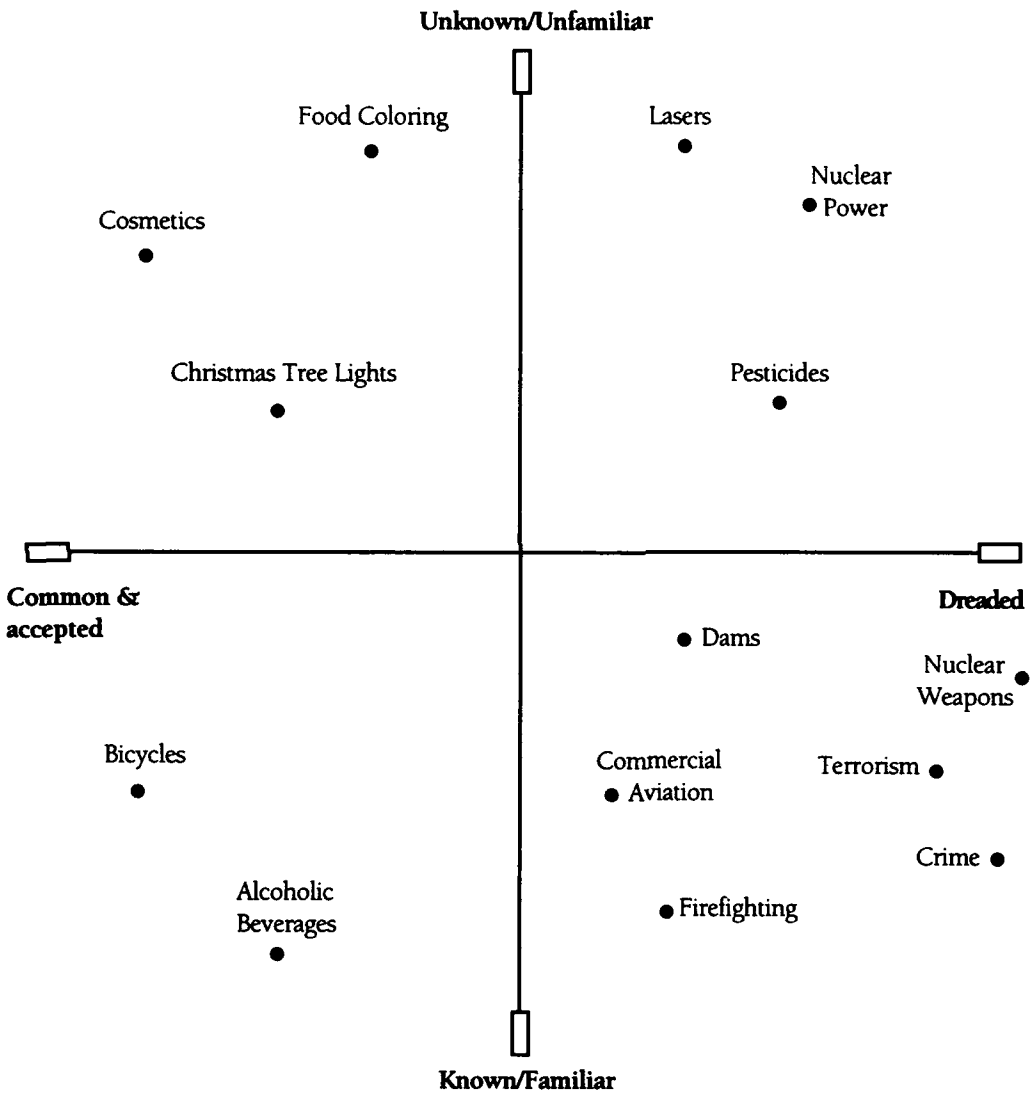
B. The dimensions on which they were ranked:

1. Is hazard accepted voluntarily?
2. Is the risk of death immediate?
3. To what extent are risks known to persons exposed?
4. To what extent are risks known to science?
5. Is this risk new and novel or old and familiar?
6. Does the risk have a chronic or a catastrophic effect?
7. Have people learned to live with this hazard or is it dreaded?
8. How likely is a mishap to cause death?
9. Can mishaps be prevented?
10. If a mishap occurs, can the damage be controlled?
11. How many people are exposed to this hazard?
12. Does the hazard threaten future generations?
13. Are you personally at risk from this hazard?
14. Are the benefits equitably distributed among those at risk?
15. Does the hazard threaten global catastrophe?
16. Are the damage-producing processes observable as they occur?
17. Are the risks increasing or decreasing?
18. Can the risks be reduced easily?

Source: Paul Slovic, Baruch Fischhoff, and Sarah Lichtenstein 1980, pp. 181-216

Figure IV-4

Rankings of Hazards: A Few Examples



Source: Slovic et al. 1980, p. 201

The question is, What does all this mean? That lay people misperceive "risk"? Or do they understand a richer notion of "risk" than is captured by probabilities of death (or average fatalities per year in a given population)? The latter is probably the case, a finding with profound implications for communication about collective risks between responsible public agencies and concerned populations.

Lay people have a very rich notion of "riskiness," one involving many dimensions other than probabilities of death for exposed populations.

We turn, in the next chapter to another source of problems with individual and collective decisions in risky situations. This takes the discussion to the collective or social level, describing some of the special problems that arise because our ultimate interest is in managing risks to groups, not in how individuals think about gambles over alternative used cars.

Conclusions

Once individuals have attended to and filtered external information concerning risky decisions, they are in a position to process what has survived. The literature on risk perception and the actual behavior of people in the face of uncertainty—whether the task be guessing at probabilities or choosing among alternative "gambles"—compares that evidence of such processing to the benchmark of the normative model set out in Chapter II. In general, the conclusions of that literature find individuals wanting. In summary:

- They neither judge nor manipulate probabilities correctly.
- They seize on spectacular information and dismiss the judgments of experts.
- They often exhibit or rather appear to work from utility-weighting schemes that would lead toward very nonconservative behavior, though in other settings they seem to favor explicitly conservation options.
- They are prone to inconsistency and even blatantly irrational decisions in the face of real, albeit, not familiar or weighty choices.

On the other side, it must be acknowledged that:

- Generally, being good at probability estimation is probably not very important to success or even survival of individuals.
- Spectacular events are easy to learn about. The commonplace, beyond that in our own lives, must be sought out.
- Subjective utility-weighting patterns can and, in general, should look different for different outcome ranges. Laboratory experiments can only cover a tiny part of the range people see in everyday life.
- The restricted range of laboratory experiments involving actual rewards and the hypothetical nature of questions probing such apparent contradictions as the Allais paradox may very well imply that much of the observed intentions and behavior represent minimum effort at decision making.
- Lay people have a very rich notion of "riskiness," one involving many dimensions other than probabilities of death for exposed populations.

Chapter V

Social Pressure and Amplification

In Chapter II (Figure II-3 and the accompanying text) we chose to portray external social pressures on individuals as influencing the processes of filtration and cognition. This kept our schematic "model" fairly tidy and helped us to organize our discussion. But the reader should be warned that although two decades of research have created a substantial base for understanding how people perceive and respond to risk, we lack a comprehensive concept of the social experience of risk, that is, the social processing of uncertainty and the perception and evaluation of expected consequences related to an event or activity (Luhmann 1990). The social science approaches to risks constitute a patchwork of many different schools and perspectives.

As discussed in Chapters II, III, and IV, psychological research into risk perception has revealed that contextual factors shape individual risk estimations and evaluations (Slovic 1987; Renn 1990). The identification of these factors, such as voluntariness, personal ability to influence risks, familiarity with the hazard, and the catastrophic potential provides useful information about the elements that individuals process for constructing their interpretation of risks. In addition, analyses of people's heuristics in making inferences have shed some light on how risk information is generalized and evaluated intuitively (Kahneman and Tversky 1979). These psychological studies fail to explain, however, why individuals select certain characteristics of risks and ignore others. More broadly, by focusing only on the individual as an information processor, these studies exclude from the analysis the social and cultural variance of risk interpretations.

Sociological analysis provides some further insights into the social and organizational factors that influence risk perception (May 1989; Clark 1989). Some studies attempt to identify social influences in the formation and change of attitudes toward risk-bearing activities or technologies (Short 1984, 1989; Gould et al. 1988). Some aspects, such as perceived fairness in the distribution of risks and benefits, have gained special attention as part of the dynamic interaction among the various groups involved in rejecting or legitimizing a proposed imposition of a risk on a special population (Kasperson and Kasperson 1983; MacLean 1986; Rayner and Cantor 1987). More theoretically oriented studies have emphasized the social construction of risk interpretations and their affinity to different types of knowledge acquisition, social interests, and cultural values (Bradbury 1989).

These sociological studies have been valuable for understanding the variability of risk interpretations among different groups and for pointing out the organizational problems that aggravate the potential outcomes of risks due to institutional constraints that impede effective risk management and control (Short 1984; Freudenburg 1988). However, they remain scattered and often fragmented and fail to link scientific assessments, individual perceptions, and the social and cultural experience of risk.

Coherence and plausibility are characteristics of the cultural approach to risk developed by such thinkers as Douglas, Rayner, Schwarz, Thompson, and Wildavsky (Douglas and Wildavsky 1982; Rayner 1987; Schwarz and Thompson 1990). According to this approach, cultural beliefs and world views determine how people experience and interpret risk. This notion is intrinsically plausible because we recognize that a substantial part of who we are—how we view the world; how we think about and interpret what we experience; how we see our responsibilities to our fellow humans; and so on—is determined by our socialization within a particular society. As children, we learn from our parents, older siblings, and other adults what is expected of us in most normal situations in life. We also learn the habit, to a greater or lesser extent, of checking our feelings, deductions, actions, and reactions with those of others. This generally shared habit is what leads to substantial coherence within society in matters such as how we generally view natural hazards and how we respond to a particular and immediate threat to life or limb.

...cultural beliefs and world views determine how people experience and interpret risk.

We consider social learning and interaction under four broad headings in roughly increasing order of narrowness of focus:

- General cultural background and world view
- More specific groupings of individuals within our culture based on their attitudes toward hierarchy, procedural rules, and cohesiveness
- Political considerations and the potential for manipulation of risks and risk information as part of the political process
- The social amplification of risk

General Cultural Background

"Scientific coping style" refers to the tendency of professionals who study risk response to deal with the world in a very particular way: one that involves the use of rationality to deal with problems and to overcome obstacles, and one that involves taming unknown phenomena by systematically achieving understanding of the principles by which these phenomena operate (Fenichel 1939). This tendency, rooted as it is in the scientific method, is certainly not all bad. In fact, it is arguably the springboard of Western civilization.

What may be problematic is that as a personal coping method this scientific style may lead to important blind spots about human functioning, about one's own responses as well as those of others. Thus, for example, it has led risk managers to view their analysis of risk as an objective lens through which reality is brought into clear focus and to assume that this scientific coping style is universal. As we have seen, those with a less scientific bent (i.e., the public), when faced with dangerous, unknown forces, may react in irrational ways that in the extreme do not serve economic gain, physical safety, or even value maintenance.

Very roughly speaking, what this says to planners and decision makers in agencies such as the Corps of Engineers is that even if it could be pointed out to the members of the public that their information filters were arbitrary or too efficient; even if they could be

chided each time a faulty probability estimate were made or manipulation completed; even if evidence of irrationality could be pointed out to them, they might very well not care. If the coping style they learned valued emotion rather than logic, the "normative" model would be a curiosity, not an ideal. In short, providing facts about the issue or decision at hand may not help. The only option open for engendering dialogue may be a more fundamental discussion of why even a minimal notion of protecting ourselves must involve us with some version of the normative model.

Cultural Group Affiliations

In recent years, anthropologists and cultural sociologists have investigated the social response to risk and have identified four or five patterns of value clusters that separate different cultural groups from each other (Schwarz and Thompson 1980). These different groups have formed specific positions on risk topics and have developed corresponding attitudes and strategies. They differ in the degree of group cohesiveness (the extent to which someone finds identity in a social group) and in the degree of "grid" (the extent to which someone accepts and respects a formal system of hierarchy and procedural rules).

According to this literature, there are four major groups in modern society that are likely to enter the risk arena: the entrepreneurs, the egalitarians, the bureaucrats, and the stratified individuals. Members of the entrepreneurial group are convinced that risk taking provides them with opportunities to succeed in a competitive market and to pursue their personal goals (Rayner 1987, p. 13). They are less concerned about equity issues and would like the government to refrain from extensive regulation or risk management efforts. This group contrasts most with the egalitarian group, which emphasizes cooperation and equality rather than competition and freedom. Egalitarians focus on long-term effects of human activities and are more likely to abandon an activity (even if they perceive it as beneficial to them) than to take chances. They are particularly concerned about equity. The third group, the bureaucrats, relies on rules and procedures to cope with uncertainty. As long as risks are managed by a capable institution and coping strategies have been provided for all eventualities, there is no need to worry about risks. Bureaucrats believe in the effectiveness of organizational skills and practices and regard a problem as solved when a procedure to deal with its institutional management is in place. The fourth group, the atomized or stratified individuals, are either part of a hierarchy or believe in hierarchy, but they do not identify with the hierarchy to which they belong. These people trust only themselves, are often confused about risk issues, and are likely to take high risks for themselves but oppose any risk that they feel is imposed on them. At the same time, however, they see life as a lottery and are often unable to link harm to a concrete cause (Thompson 1980).

The practical utility of these insights would be greater if it could be anticipated that membership in the groups were distributed systematically, for example, with respect to region or risk management setting. Then planners and decision makers could take advantage of what is understood about group assumptions and reactions when structuring a program of risk communication. In the absence of such convenient systematic patterns, it is probably

safe to assume the distribution of group membership to be random across regions and decision areas. Then recognition of the existence of such groups just sensitizes the risk communicator to some of the possibilities for foul-ups.

Risk in the Political Arena

Beyond the problem of distrust in risk management institutions, risk debates take place in a political context in which risk reduction may only be one objective among others. Using the metaphor of a sporting arena, social conflicts can be described as struggles between various players, controlled by a rule enforcement agency (usually a governmental institution) and observed by professional reporters (the media) who interpret the actions on the stage and transmit their stories to a larger audience (Lowi 1967; O'Riordan 1983).

The inherent uncertainty of risk assessments provides sufficient flexibility to "support" conflicting evidence and claims.

To be successful in a social arena, it is necessary to mobilize social resources. These resources can be used to gain the attention and support of the general public, to influence the arena rules, and to "score" in the arena in competition with the other actors. Social resources include money, power, social influence, value commitment, and evidence. Money provides incentives (or compensation) for gaining support. Power is the legally attributed right to impose a decision on others. Social influence produces a social commitment to find support through solidarity. Value commitment induces support through persuasion and trust, while evidence can be used to convince persons about the likely consequences of their own actions. Resources are not only the ends but also the means to accomplish other goals.

Actors will enter the risk arena if they expect this will provide them with an opportunity to gain more resources (Kitschelt 1986; Dietz et al. 1989). Beyond their reservoir of resources at any time, they can gain more resources by exchanging one resource for another (e.g., winning public trust by sharing power through participation or exchanging evidence for prestige) and by communicating to other actors and the media. The objective of communication is to receive public support and to mobilize other groups for one's own cause. The more resources a group can mobilize in an arena, the more likely it is that it dominates the conflict resolution process and gets its point of view incorporated in the final decision.

Actors may use the arena to gain more resources even when the topic of the arena is not of central importance to them. They can use risk as a vehicle to get their message across and to mobilize public support. Risks are then linked with other topics such as business ethics, consumerism, or lifestyle changes. These linkages may or may not reflect logical connections; they can be based on associations or plausibility. They are constructed by social groups as a means to mobilize resources.

The inherent uncertainty of risk assessments provides sufficient flexibility to "support" conflicting evidence and claims. Because of the weak position of the rule-enforcement agencies, risk arenas tend to experience more rule innovations than other arenas in which strong enforcement agencies are present. In arenas with high ambiguity of the political issue, weak status of the rule-enforcement agency, and a lack of immediate personal experience about the potential consequences

of political decisions, the distribution of resources relies almost entirely on the success of one's communication efforts.

In general, then, the Corps of Engineers can at the very least expect that its own risk communication efforts will not constitute the only game in town, whenever there is a high- (or even moderate) stakes decision on the line. The Corps has to be prepared to be attacked for its assumptions, methods, conclusions, and its motives for all of the above. How it responds to such a critique may prove at least as important as the style and content of its primary message in determining the outcome of what, at that point, will have become a contest or controversy, not just an issue.

Social Amplification of Risk

An individual will often look to others to determine what his reaction to threat should be. The group may serve to alert the unsuspecting individual to danger or to give false reassurance to each of its members, because everyone is looking to other members for cues regarding danger (Begum and Ahmen 1986; Lamm 1988). This prosaic but fundamental observation may help to motivate the more complex notion of the social amplification of risk as proposed in 1988 by Kasperson and his colleagues (Kasperson et al. 1988).

This concept of social amplification is based on the thesis that events pertaining to hazards interact with psychological, social, institutional, and cultural events and shape risk behavior. Behavioral patterns, in turn, generate secondary social or economic consequences that extend far beyond direct harms to human health or the environment, including significant indirect impacts such as liability, insurance costs, loss of confidence in institutions, or alienation from community affairs. Such secondary effects often trigger demands for additional institutional responses and protective actions or, conversely (in the case of risk attenuation), place impediments in the path of needed protective actions. In accordance with the metaphor of amplification in the processing of electronic signals, "amplification" includes both intensifying and attenuating signals about risk. Thus, alleged overreaction of target audiences receives the same attention as alleged "downplaying."

An individual will often look to others to determine what his reaction to threat should be.

The amplification process starts with either a physical event (such as an accident) or the recognition of an adverse effect (such as the discovery of the ozone hole.) In both cases, individuals or groups will select specific characteristics of these events or aspects of the studies and interpret them according to their perceptions and mental schemes. These interpretations are formed into a message and communicated to other individuals and groups. Upon receiving the messages, these social groups or individuals process the information and may feel compelled to respond. Some may change their previously held beliefs, some may gain additional knowledge, some may be motivated to take actions, and others may use the opportunity to compose a new message that they will send to the original sources or other interested parties (Renn 1991).

Individuals or groups collect and respond to information about risks and act as "amplification stations" through behavioral responses or communication. Amplification stations can be individuals, groups, or institutions. It is obvious that social groups or institutions can

amplify signals or consequences only via the actions of individuals working in those social aggregates. But individuals in groups and institutions do not act or react predominantly in their role as private persons but, rather, according to the role specification associated with their positions. Amplification during reception may therefore differ among individuals in their roles as private citizens and in their roles as employees or members of social groups and public institutions. Amplification occurs on the communication (signals) and consequence level (behavioral responses).

...the only viable resolution of conflict in democratic societies is achieved by initiating discussion among the major parties involved in the decision-making process...

The social amplification framework provides an integrative concept. The distinction between individual and social amplification stations corresponds with the two traditions in risk perception: the individual processing of information and the social responses to risk based on experience of (dis)trust, the political arena conditions, and cultural affiliations. It provides a more holistic picture of the risk perception process and takes into account psychological, sociological, and cultural aspects.

Conclusions

Although risk perceptions differ considerably among social and cultural groups, the integration of beliefs related to risk, the cause of risk, and its circumstances, into a consistent belief system appear to be common characteristics of public risk perception in almost all countries in which such studies have been performed (Renn 1989). These perceptions reflect the real concerns of people and include the undesirable effects that the technical analyses of risk often miss. Social risk perception studies, then, can contribute to improving risk policies in several ways (Fischhoff 1985):

- They can identify and explain public concerns associated with the risk source.
- They can explain the context of the risk-taking situation.
- They can identify cultural meanings and associations linked with special risk areas.
- Based on this knowledge, they can help to articulate objectives of risk policies, in addition to risk reduction, such as fairness, procedural equity, vulnerability, and institutional trust.
- They can provide a foundation for the design of procedures or policies to incorporate these cultural values into the decision making process.
- They can help responsible agencies design programs for evaluating risk management performance and organizational structures for monitoring and controlling risks.

There is no impartial referee available to judge the appropriateness of risk perceptions. Science may help to determine the magnitude of the risk, but the only viable resolution of conflict in democratic societies is achieved by initiating discussion among the major parties involved in the decision-making process or affected by the decision outcomes (Habermas 1971). Such a dialogue can be organized in the form of advisory committees, citizens panels, formal hearings, or in other ways (Fiorino 1989).

Chapter VI

Guidelines for Risk Communication

Framework

There are four elements of the risk communication process that need to be considered by the planner:

1. *Objective(s)*, that is, what is the risk issue? Who constitutes the audience? Why is the communication being undertaken?

2. *Contents* of the message, that is, what information is to be conveyed in order to accomplish the objectives?

3. *Form of communication*, that is, how should the message be transmitted from the source to the receiver?

4. *Feedback from the audience*, that is, what is being received?

The objectives depend on the problem or environmental hazard at hand. Two broad alternative objectives are (1) the planner may want to provide the audience with a better understanding of the risk and uncertainties surrounding planning alternatives and thus to stimulate cogent and informed discussion—and ultimately a defensible resolution, or (2) the planner may desire to communicate risk in order to encourage appropriate behavior by individuals and communities. Undoubtedly there are other objectives.

The characteristics of the four elements of the risk communication process are determined by the audience being addressed. There are two very different audiences that the planner has to communicate with: (1) Corps and governmental (federal, state, and local) decision makers and (2) the general public. Planners must tailor the communication techniques to the particular group they are dealing with at the time. There are distinct differences in how risks are presented to each group.

The presentation of risk to decision makers is similar, yet different from the presentation to the public. The basis for this divergence is the different role each group plays in the planning process, leading to a variation in the content and form of the risk communication between the two audiences. The difference between the two groups can be summarized as follows: decision makers may require a greater level of detail in their information about the risk of the project than is needed by the public. The content and form of the risk communication with these groups reflects these differences.

The type of data provided to the decision makers by the planner reflects the nature of the decision maker's job. In order to make informed decisions about risk, information such as advanced statistical analysis is used by the planner to develop alternatives for the consideration of decision makers.

Examples of technical data are the probabilities and associated probability distributions of the various risks. The same level of detail is not generally needed for communication with the public. The public's ability to understand and analyze the detailed information used by decision makers, such as statistical analysis, is usually limited. Therefore, it is important that the appropriate content and format of communicating risk be used when addressing the public. These concepts are discussed in detail in this chapter.

Feedback is essential to successful communication programs in every setting. The presence of risk raises the ante. The most manageable and economical way to obtain feedback is to convene one or more *focus groups*.

The manner in which information is actually communicated between the planner and the audience is another difference in the communication process. Information flowing from the planner to the decision maker is usually transmitted in the form of written documents such as Corps reconnaissance and feasibility reports, and internal meetings. The public is usually given information through town or neighborhood meetings, television and radio spots, newspaper advertisements, and brochures. The reconnaissance and feasibility reports used by decision makers are available for the public to read. However, these types of reports tend to be technical in nature and more difficult for the general public to understand. In the interest of conveying the risks and the options available to deal with the risks, it is usually best for the planner to describe the situation in nontechnical terms.

The *contents* and *form* of the message are both important and distinguishable. Thus, it is helpful to think about risk communication in terms of "*what* you tell them" and "*how* you tell them." One other element is essential and that is to check what is actually getting through to the intended audience, through soliciting *feedback*.

The specifics of content, form and feedback, and the guidelines suggested here for dealing with those elements of the process differ significantly depending on the objective of the exercise. The key considerations in design of form are common to both objectives. Thus, for example, when the objective is to influence understanding, it is especially important that the content of the risk communication message come to grips with the cognitive problems identified in Chapter II. For example, care must be taken in the expression of probabilities and in the framing of the decision consequences. On the other hand, when action is the desired objective, the contents of the message must be sensitive to the *factors that motivate* individuals to take actions (as discussed in Chapter III) and must deal explicitly with the actions desired. In other words, tell them what you want them to do, why you want them to do it, and how should they go about doing it. This approach is equally suited for an audience of internal or external decision makers as well as the public in general.

In designing a format for the communication, however, far more commonality exists between the objectives. Thus, a message should always be vivid and personalized, concise and concrete. Whenever possible it should be delivered in person to small groups and should be reinforced by an authoritative local figure.

Feedback is essential to successful communication programs in every setting. The

presence of risk raises the ante. The most manageable and economical way to obtain feedback is to convene one or more *focus groups*. Such groups allow in-depth discussion of issues and problems in a nonthreatening setting and, while not producing statistically representative information, can nonetheless alert the program manager to needed adjustments in strategy and tactics. But what the focus groups can most usefully probe varies with the objective. In a program aimed at enhancing understanding of a risky decision setting, the cognitive threats to understanding have to be the first concern. In a program aimed at stimulating action in the face of risk, the perceptions of the community as they relate to desirability, fairness, and seriousness of purpose must be gauged.

■

General Guidelines on Risk Communication Content

In this section, ten guidelines for the content of risk communication are set out and discussed, five for each of the objectives: understanding and action. These are summarized in Table VI-1.

When Understanding Is the Objective

Perceiving Natural Processes and Probabilities

As we have noted, there is substantial evidence (and most of us can probably testify through personal experience) that it is common for people to have trouble estimating, manipulating, and understanding the implications of probabilities of uncertain events.[10] When understanding in a planning context is at stake, it is prudent to:

> *Express uncertainty in a variety of ways while avoiding modes of expression that encourage or seem to confirm beliefs in the cyclicity or supernatural purpose of natural events.*

For example, in order to breathe life into the notion that the probability of a flood on a particular river at a particular place in a particular year is 0.01, it has been thought useful to say that the "return frequency" of such a flood is 100 years. The problem with this otherwise obvious transformation is that it gives ammunition to the brain's disinclination to think in terms of independent events. If such a flood occurs in year *t*, the brain would like to say that now we will not have to worry about that again for *t* plus one hundred years, well beyond our lifetime. This is not a very useful view of the natural world.

An alternative is to dream up physical analogies to the 0.01 probability. Philosophers, for example, like to talk about pistols that have *t* chambers and one bullet, and the exercise is thought of as Russian roulette with that pistol. An alternative might be a wheel of fortune on a carnival midway or something involving colored Ping-Pong balls in jars. The key point is to make it clear that the pistol cylinder or the wheel of fortune is spun, or a drawing is made from the jar *every year* and that the same probabilities apply every time.[11]

■

...it has been thought useful to say that the "return frequency" of such a flood is 100 years. The problem ... is that it gives ammunition to the brain's disinclination to think in terms of independent events.

■

[10] E.g., on probabilities of natural hazards–Kates 1962, White 1964; on using new information to update existing estimates–Tversky and Kahneman 1980; and making estimates of probabilities, especially of rare events–Slovic et al. 1982; Lichtenstein, et al. 1982; Fischoff 1988.

[11] The pistol figure breaks down in the multiple year context as soon as we have a flood (bullet) because there is no tomorrow in failed Russian roulette.

Table VI-1

Principles And Guidelines for Risk Communication: A Schematic

Objectives	Understanding in the Planning Context	Action in the Management Context
Content	Express uncertainty in several ways but in general avoid feeding into problems with independence. (e.g.: don't use recurrence intervals.)	Emphasize seriousness but not powerlessness.
	Give ranges of probabilities and outcome measures whenever experts differ.	Reinforce socially responsible behavior.
	Frame the decision problem in different ways; at least as gains relative to worst case and as losses relative to best case.	Affirm possibility of mitigating impacts through desired action.
	Stress analogy of project to insurance wherever applicable.	Stress equity of sacrifice being requested.
	Provide relative risk information in a schematic way.	Publicize model behavior by respected local citizens where possible.
Format	• Make message vivid. • Use authoritative source. • Make message clear, concise and concrete. • Personalize the message. • Deliver the message in person to small groups. • Multiple messages should contain common theme.	
Feedback	Use Focus Groups to Probe:	
	• For cyclical or supernatural views of natural-world uncertainty	• Perceived relative desirability of alternative possible actions
	• For presence of risk-prone utility patterns over losses	• Perceived actions by others in community
	• Meaning of expressed preferences for particular decisions, using willingness-to-pay format	• Effectiveness of monitoring and enforcement regime, if any
		• Regressive behavior

Acknowledging Differences in Expert Opinion

Although much of the Corps planning work does inevitably involve uncertainty, one of the most common sources of that uncertainty is hydrology, an area in which historical records and well-tested methods leave little room for differences of expert opinion. Whenever Corps decisions involve some other environmental variables, however, such differences are almost inevitable, reflecting the tenuous state of our ecological knowledge. Thus, ask a dozen experts how tinkering with a particular wetland will affect downstream water quality or populations of particular plant or animal species, and you are liable to get at least half that many answers.

The temptations in such a situation are, first, not to ask more than one expert, and that one being a person with whom the planner has had experience and, second, when other opinions do come to light, to try to keep them out of the public discussion. The downside of this strategy is that it feeds, in a remarkably efficient way, the latent (or not so latent) mistrust that some citizens may harbor for the Corps.

Therefore:

> *Risk communication should acknowledge and report on differences in expert opinion with regard to the outcomes to be expected from proposed actions. Every effort should be made to express the range of opinion in symmetric terms and to use the language of risk and uncertainty.*

If the first part of this principle seems to cut against the grain for professional engineers, the second part may pose even greater problems once the first has been accepted. This is because much expert analysis and prediction about the natural environment is expressed in certain, rather than uncertain, terms. Thus, each expert is likely to say, "This will happen." You will seldom hear, "This will happen with probability one-half, that with probability one-quarter, and something quite different from either with probability one-quarter." In this sort of situation, the easy way out is to report the range of predictions and leave the audience to deal with that range as it will. More difficult, but also more productive for the long-run continuing dialogue the Corps must have with its citizen clients, is to use the techniques developed by decision analysts to discover the subjective probability estimates that the experts hold but do not usually express. A somewhat less satisfactory, but still useful, exercise, if those involved locally will not play the game, is to bring in an independent expert to make the probability judgments.

...ask a dozen experts how tinkering with a particular wetland will affect downstream water quality..., and you are liable to get at least half that many answers.

To understand how this might work, consider an entirely hypothetical example and a subset of the sort of questions an analyst (A) might ask an expert subject (E). (This example is adapted from material in Raiffa, 1970). For consistency with the next example, we shall use the example of the proposed flooding of a locally important wetland. It is downstream from a developed residential area (including a golf course) and upstream of a substantial length of stream that is used for recreation and drinking water. This flooding could occur because increasing emphasis on flat-water recreation within the reservoir just below the wetland makes it desirable to raise the level of water maintained on average behind the dam.

One question of interest to the public might be, What will happen to the level of nutrients in the stream below the reservoir? (Nutrients would affect both the recreational and water-supply uses of the stream. Recreation value would be reduced if an increased nutrient load led to algal blooms, periodic oxygen reduction, and loss of ability to support game fish. Water supply costs could increase because of the health threat believed to be posed by nitrates in drinking water.) Because the nutrient sequestration function of wetlands is not precisely understood and modeled, there will probably be a range of answers to this question—let's say that range runs from zero increase to a doubling on average, with no one certain about the outcome . In such a situation, A would ask E questions of the form:

> Give me a value for the increase in nutrient concentrations such that it would be extremely hard for you to make up your mind to choose an answer above or below it; that is, a value such that you think it as likely that the increase will prove to be above it as it is likely to be below it.

Once such a value has been obtained, call it N*. A then goes on to press E to subdivide the intervals above and below N* into equally likely subintervals. (That is, E is asked to divide 0 to N* and N* to 2 by numbers N** and N*** such that

$$P(0 < N < N^{**}) = P(N^{**} < N < N^{*}) = P(N^{*} < N < N^{***}) = P(N^{***} < N < 2.0) = 0.25$$

This process may be repeated as long as E will stand for it and as long as the problem setting seems to justify it. The result can be shown as a density histogram or as a distribution function, smoothed and used in calculations if desired.

Framing the Outcomes from Alternative Projects or Policies

We know from experimental social psychology that there is a good chance people will respond differently to two versions of a mathematically identical choice, if one is expressed as gains and the other as losses (Kahneman and Tversky 1982). Accordingly, it is worthwhile, when possible, to:

> *Express the outcomes from contemplated alternatives both as losses from a best case and as gains from a worst case, explicitly pointing out that the two formulations are identical.*

Following this principle will not always be easy, but to illustrate what is involved, let us follow up on the simple example introduced above. Assume an office of the Corps is considering an increase in the frequency of higher water levels in a reservoir with the aim of improving summer recreation availability. The results will include the gain of 50 recreation days; the flooding of a productive wetland, which in turn could lead to local loss of wetland plants (perhaps half the total number of plants species present in the reservoir area); gain of 100 acres of prime largemouth bass fishing; loss of nutrient sequestration and doubling of nitrogen and phosphorus loads in the stream below the reservoir. To summarize, the best and worst outcomes are presented in Table VI-2. Other dimensions such as cost and outputs of peaking power or flood control would in general have to be included. But they would only clutter v [illegible] luminating in the example. Usi [illegible] and worst benchmarks,

Table VI-2

Best and Worst Outcomes

Best Outcomes	Worst Outcomes
50 days of recreation gained	No gain in recreation days
No plant species lost	One-half of species lost
100 acres of bass fishing gained	No gain in bass fishing
No deterioration in water quality	Doubling of nutrient loads downstream

Table VI-3

Outcome Information

	Increase Frequency of High Water Levels	Leave Levels as They Are
Losses from best case	No loss of recreation days	Loss of 50 recreation days due to low water levels
	One-half species lost	No loss of species
	No loss of fishing	Loss of 100 acres of fishing
	Doubling of nutrient loads downstream	No water-quality deterioration downstream
Gains from worst case	Gain of 50 recreation days	No gain from worst case
	No gain from worst case	One-half of species saved
	100 acres of fishing created	No gain from worst case (no fishing created)
	No gain from worst case	Nutrient loads one-half of worst case

the planner could then provide outcome information along the following lines (though not necessarily in the following format) as shown in Table VI-3.

The point of the exercise is that individuals in the audience will probably be creating their own best- and worst-case benchmarks and may respond differently to the same proposal, depending on which base they focus on. Giving them a range of ways of thinking about the choice may help them to see more clearly which way their interests lie. The effort is more likely to be worthwhile the more emotionally loaded the elements of the outcome. Human deaths (or lives "saved") are probably the most loaded and "mere" dollars the least.

Perhaps the most effective way of presenting information emphasizing the insurance aspect of a situation is through a distribution that attaches probabilities to outcomes...

Understanding the Insurance Analogy

In some, though by no means all, Corps planning, an element of insurance purchase is implicit. For example, flood control projects shift the probability distributions over losses of human lives and over damages to structures and their contents. The annualized costs of the structures involved may be seen as the premiums for the shifts. Similarly, municipal water supply projects shift the probability distributions for the receiving utilities of their capacities to deliver water under different rainfall (or lack of rainfall) events. These shifts, in turn, change the probability distributions of losses suffered by customers when restrictions have to be imposed in order to save water to prevent much greater losses later, if the drought event continues.

The audience for risk communication in such situations may need to be reminded why insurance exists, how the costs of the project in question may be seen as premiums on a policy, and how both premium and the outcome being insured against would affect individuals and communities. This suggestion is made for two reasons. First, the cognitive-problems literature surveyed in Chapter IV suggests that in laboratory experiments and surveys, where no real gains or losses are at stake, individuals exhibit risk-prone or risk-seeking utility patterns over losses (Kahneman and Tversky 1982). (This means that these individuals would refuse to purchase insurance unless the premium charged was even lower than the expected value of the loss being insured against). Second, the actual nature of insurance arrangements with which individuals are familiar from daily life has been distorted away from protection against catastrophic loss and into a prepayment plan for routine bills. Accordingly:

> *Whenever large losses are possible, whether in the absence of or because of Corps actions or decisions, an effort should be made to communicate the variance or at least the range of outcomes in addition to what is said about expected outcomes.*

It is our contention that in the face of the prospect of real losses of a catastrophic nature—the best example for the Corps being losses from urban flooding—risk averse preferences are more likely than risk seeking. But so long as communications stress expected values, the range of outcomes remains buried. Perhaps the most effective way of presenting information emphasizing the insurance aspect of a situation is through a distribution that attaches probabilities to outcomes (dollars, lives lost, etc.). An example of how comparative distributions can

be used to present this kind of information is shown in Figure VI-1 (histograms can also be useful visual aids). An alternative tabular presentation of the same material is shown in Table VI-4. The project benefits distribution in Table VI-4 is estimated based upon sampling from the with and without project EAD distributions in Figure VI-1.

Setting the Risk in Perspective

Our survey of the literature on how lay people deal with risk included some observations on the evidence concerning common problems with the lay ranking of the "riskiness" (a multidimensional notion) of many activities and situations. Two of those observations are especially pertinent here. First, lay people and experts commonly differ on their assessments of riskiness. This is quite possibly because lay people, though often lacking complete information, are working with complicated models of what constitutes riskiness. Experts, on the other hand, tend to concentrate on the probability-of-death dimension. Second, lay people often seem to view as relatively safe common, but rather dangerous activities, such as smoking or drinking and driving, while perceiving such exotic activities as mountain climbing and such quite safe, but much less familiar actions, as being vaccinated, as very risky (Slovic et al. 1980). An individual's risk perception is also influenced by personal experience. For example, if a person had the experience of actually being in a flood, their short-term perception of flood risk may be different from someone who had never experienced a flood. The person who was a flood victim in the past may perceive a flood to be more damaging or deadly than it really is. Accordingly, we suggest the following principle:

Whenever a planning or decision problem involves potential loss of life, provide a context for the problem-specific information in the

Figure VI-I
Expected Annual Damage and Benefit Distributions

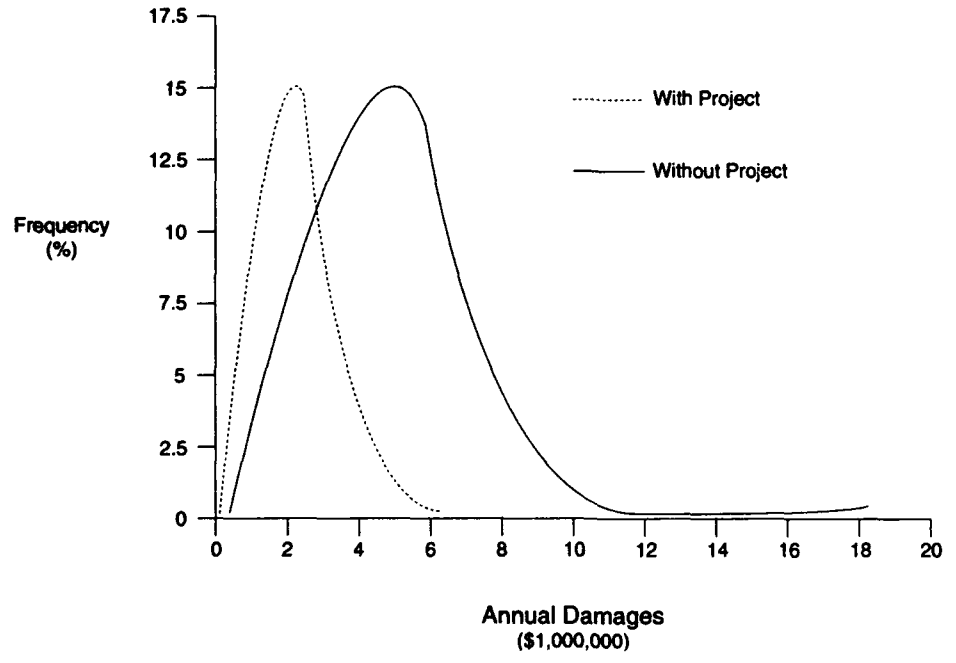


TABLE VI-4

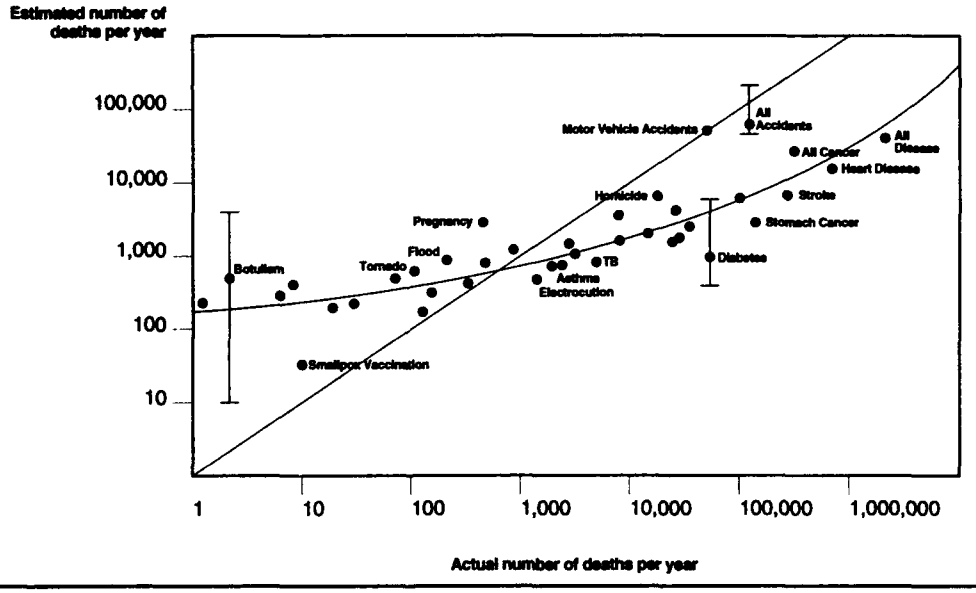
Expected Annual Damage (EAD) and Benefit Distributions (Millions of Dollars)

	EAD Without Project	EAD With Project	Project Benefits
Mean	5.501	2.658	2.843
Minimum	0.755	0.297	0
Maximum	16.924	8.154	14.580
Range	16.168	7.857	14.580
Standard Deviation	2.479	1.056	2.417

Source: Greeley-Polhemus Group, Inc. (1992b), pages FC-45 to FC-47.

Figure VI-2

Estimated Versus Actual Ranking of Risk



Source: Starr and Whipple 1980.

Table VI-5

Risks That Increase Chance of Death by 0.000001[1]

Smoking 1.4 cigarettes	Cancer, heart disease
Drinking 1/2 liter of wine	Cirrhosis of the liver
Spending 1 hour in a coal mine	Black lung disease
Spending 3 hours in a coal mine	Accident
Living 2 days in New York or Boston	Air pollution
Travelling 6 minutes by canoe	Accident
Travelling 10 miles by bicycle	Accident
Travelling 300 miles by car	Accident
Flying 1,000 miles by jet	Accident
Flying 6,000 miles by jet	Cancer caused by cosmic radiation
Living 2 months in Denver on vacation from N.Y.	Cancer caused by cosmic radiation
Living 2 months in average stone or brick building	Cancer caused by natural radioactivity
One chest X-ray taken in a good hospital	Cancer caused by radiation
Living 2 months with a cigarette smoker	Cancer, heart disease
Eating 40 tablespoons of peanut butter	Liver cancer caused by aflatoxin B
Drinking Miami drinking water for 1 year	Cancer caused by chloroform
Drinking 30 12 oz. cans of diet soda	Cancer caused by saccharin
Living 5 years at site boundary of a typical nuclear power plant in the open	Cancer caused by radiation
Drinking 1,000 24 oz. soft drinks from recently banned plastic bottles	Cancer from acrylonitrile monomer
Living 20 years near PVC plant	Cancer caused by vinyl chloride (1976 standard)
Living 150 years within 20 miles of a nuclear power plant	Cancer caused by radiation
Eating 100 charcoal broiled steaks	Cancer from benzopyrene
Risk of accident by living within 5 miles of a nuclear reactor for 50 years	Cancer caused by radiation

[1] (1 part in 1 million)

Source: This table is taken from "Analyzing the Daily Risks of Life" by Richard Wilson, reprinted with permission from *Technology Review*, copyright 1979, vol. 81, no. 4 (February 1979), pp. 41-46, and extracted from Glickman and Gough (1990).

form of expert-based relative risk information for many human activities and natural events.

It is important to point out that following this principle does not prejudge the issue of what determines risk acceptability. For example, it does appear that lay people perceive activities to be less risky if there seems to be some individual control present (driving drunk), and if it is possible to have had some experience with the behavior without having suffered (smoking). Publishing a relative risk comparison is unlikely to change this. But, at the very least, it can help the audience to see where the *imposed* risk under discussion seems to fit in the scheme of things. Examples of such comparisons are given here as Figure VI-2 and Table VI-5.

...it does appear that lay people perceive activities to be less risky if there seems to be some individual control present...

When Action Is the Objective

Perceived Seriousness of the Risk

The implication of past research relevant to this factor can be stated as follows:

People will make an effort to react positively if they believe that a genuine risk exists in their community.

This attitude-behavior relationship was observed as a result of surveys conducted during and after major episodes of resource shortage (both water and energy). Consumers must sense a high level of personal risk and discomforting uncertainty about an impending drought to take personal action to avoid undesirable consequences. The stimulus may be descriptive accounts and pictures of the last drought in the same geographic area showing inconveniences as well as monetary impacts. Hydrologically, it can be shown that short-term rainfall is inadequate to replenish a full soil moisture regime. The belief about the seriousness of water shortage is often stated as a necessary condition for persuading consumers to conserve.

In one of the early studies of consumers' behaviors related to the environment, White (1966) concluded that people who believed the drought of the mid-1960s was serious were likely to adopt more conservation activities and use less water on a daily per capita basis than those who believed it was not serious. The same relationship between the belief that shortages exist and that water conservation is necessary was investigated by Bruvold (1979) in a survey of 900 consumers in nine water supply districts of the San Francisco Bay area. His results showed that an index measuring the perceived seriousness of the 1976-77 California drought by each survey respondent was the best predictor of personal conservation effort. Also, in a survey of 195 residential consumers in Goleta, California (Talarowski and McClintock 1978), the respondents who used more water than their district-imposed allotments perceived the California drought as less serious than did other respondents. Some other risk qualities that make a difference in people's judgements are shown in Table VI-6.

These results seem to be replicated in survey research in the area of energy conservation. For example, Thompson and McTavish (1976) found that about 20 percent of respondents believed in present or future energy shortages; it was these individuals who reported practicing significantly more conservation measures than the respondents who did not hold such beliefs. Similar studies can be conducted by Corps planners to assess public perceptions of the seriousness of the

Table VI-6

Qualitative Factors Affecting Risk Perception and Evaluation

Factors	Conditions Associated with Increased Public Concern	Conditions Associated with Decreased Public Concern
Catastrophic potential	Fatalities and injuries grouped in time and space	Fatalities and injuries scattered and random
Familiarity	Unfamiliar	Familiar
Understanding	Mechanisms or process not understood	Mechanisms or process understood
Controllability (personal)	Uncontrollable	Controllable
Voluntariness of exposure	Involuntary	Voluntary
Effects on children	Children specifically at risk	Children not specifically at risk
Effects manifestation	Delayed effects	Immediate effects
Effects on future generations	Risk to future generations	No risk to future generations
Victim identity	Identifiable victims	Statistical victims
Dread	Effects dreaded	Effects not dreaded
Trust in institutions	Lack of trust in responsible institutions	Trust in responsible institutions
Media attention	Much media attention	Little media attention
Accident history	Major and sometimes minor accidents	No major or minor accidents
Equity	Inequitable distribution of risks and benefits	Equitable distribution of risks and benefits
Benefits	Unclear benefits	Clear benefits
Reversibility	Effects irreversible	Effects reversible
Origin	Caused by human actions or failures	Caused by acts of nature or God

NOTE: In selecting risks to be compared, it is helpful to keep these distinctions in mind. Risk comparisons that ignore these distinctions (e.g., comparing voluntary to involuntary risks) are likely to backfire unless appropriate qualifications are made.

Source: Covello et al. 1988 and extracted from National Research Council, National Academy Press 1989.

risk and follow with education programs when the perception falls short of the true magnitude of the risk. If people are made aware of the risk, they will make an effort to react with positive action to reduce that risk.

Perceived Interest of the Group

The potential for conflict between group interest and individual interest arises when some publicly supplied resource is scarce. Facing the rapid depletion of a necessary resource, the individual may choose to act selfishly, either in ignorance of, or disregard for, the ultimately undesirable long-term consequences of his or her behavior. Such a problem is often characterized as the "tragedy of the commons" (Hardin 1968) or a "social trap" (Platt 1973). It refers to a situation when property rights provide an incentive for overexploitation or rapid depletion of a resource. When informed about the risks and consequences of ecological disruption and wildlife displacement, sensitivity may mold a group consciousness that overrides individual self-interests.

The individual's beliefs about the attitudes of others in the group also strongly feature in behavior patterns.

Studies by Talarowski (1977), Marwell and Ames (1979), and Stern (1976) demonstrate that:

> *Educating and informing people about the undesirable long-term consequences of self-interested choices will be effective in cultivating strong group interest and moral concerns in the community.*

Self-interest is a more powerful determinant of behavior than group interest, and this deduction has been confirmed by laboratory experiments on the commons dilemma. Proponents of this belief have concluded that, in general, the greater the incentive for pursuing self-interested behavior, the greater the number of people who adopt this course of action (Kelley and Grzelak 1972; Talarowski 1977). However, certain conditions have been shown to influence consumers' willingness to further group welfare. Dawes, McTavish, and Shaklee (1977) noted that co-operative response dominated over self-interest when individuals were allowed to communicate freely about the commons dilemma.

The individual's beliefs about the attitudes of others in the group also strongly feature in behavior patterns. The incentive for engaging in self-interest in a laboratory commons dilemma as opposed to group-interest stems from the belief that other group members would behave in a similar fashion (Dawes, McTavish, and Shaklee 1977).

It must be remembered that laboratory simulations of commons dilemmas cannot account for the numerous complexities that surround reality. The issue of a dilemma in the real world may be a very gradual process. Furthermore, other constraints in the real-world situation, such as factors governing awareness and response habits, can influence consumer behavior (Berk et al. 1981).

Perceived Efficacy of Risk Reduction Efforts

Several studies of behavior point to a general finding that can be stated as follows:

> *An individual's belief that his/her personal effort will matter in reducing risk will increase his/her likelihood of adopting risk reduction measures.*

This relationship seems to be in agreement with the theory of fear arousal, which states that the belief in the efficacy of a coping response in avoiding a negative event is one of

the most important determinants of behavior (Rogers 1975).

Hamilton (1985) compared self-reported and actual water savings for 471 households during a conservation campaign in Concord, New Hampshire. The findings indicated that the knowledge of respondents' own water use was relatively low; however, the accuracy of self-reports showed an increase with the extent of conservation behavior. This result may be interpreted in terms of perceived efficacy of conservation efforts. Consumers are more likely to engage in conservation efforts if they know how much water they can save by doing so. This, in turn, may convince them of the importance of their personal efforts in lessening the impacts of drought.

The perception of the efficacy of personal efforts is also linked to a personality trait known as "locus of control" (Rotter 1966). Locus of control is the sense of the extent to which individuals believe they can have an influence on their lives. Thus, persons with an "internal locus" believe that what they do themselves matters; those with an "external locus" believe that forces external to themselves, such as fate or luck, direct their futures. Persons characterized as internally oriented have been found to be more efficient in gathering and utilizing information relevant to solving environmental problems (Sims et al. 1982). By contrast, persons believing that external forces control their fate and environmental events are more likely to regard personal risk reduction efforts as having little, if any, effect in alleviating the consequences of a natural hazard. This division of personality characteristics was exemplified by their study of deaths attributed to tornadoes. Higher rates of fatalities were found in geographic regions where people believed they were controlled by fate or luck. Those regions where residents felt that what they do affects their futures incurred a significantly lower death rate.

When the public believes that their personal efforts will meaningfully contribute to reduced risk, they will be more likely to take action to adopt risk reduction measures.

General Guidelines for Risk Communication Form

The theory of persuasive communication and past research suggests several important requirements in designing maximally effective messages, whether the objective is to induce understanding or action. These requirements are discussed below.

The Message Must Be Vivid and Personal

Webster's dictionary defines the adjective "vivid" as "full of vigor and freshness of the immediate experience evoking lifelike images within the mind." Therefore, a vivid message that clearly portrays the risk can be described as lively, sharp, and intense. Several studies have shown that people assign disproportionate weight to information that is very vivid (Borgida and Nisbett 1977; Yates and Aronson 1983).

A local news reporter shown on the evening news while walking along the edge of an emergency levee w[illegible]e the water has already encroached above the sandbags placed only hours earlier is much more effective in persuading individuals to take both short and long-term action to protect property and life from floodwaters than statistical reports detailing the abnormally high accumulation of rainfall in the distant mountains. This type of a vivid example presented by individuals who

When the public believes that their personal efforts will meaningfully contribute to reduced risk, they will be more likely to take action to adopt risk reduction measures.

are familiar to the community is often needed to effectively persuade residents to take action.

The Message Should Originate from a Person

Information received from another person, especially a respected friend or a colleague, is likely to have a greater impact on the decision making of the person receiving the message than impersonal information summaries. Such summaries, although based on highly representative statistical studies and conveying more accurate and efficient information, often exert less impact than less representative but more vivid and personal accounts. In the earlier example of a river rising above emergency riprap and sandbags, the local news reporter delivered the message, and the magnitude of the risk was absorbed by everyone watching the telecast. Detailed hydrological studies prepared by credible researchers with historical data and the best probability estimates would have less impact on the public than the news reporter. The reporter's account will weigh much more heavily in the resident's imagination than those of a team of unknown researchers summarized in streamflow studies. We have little doubt that it will be quite decisive in the example.

The more personal the information, the higher the likelihood that it will be perceived and processed by its receiver.

The Message Must Come from a Credible Source

Consumers will react to a message only if it is perceived as emanating from a credible source. Research shows that the credibility of the source greatly influences the effectiveness of the message (McGuire 1985). Messages from noncredible sources produce a lesser change in attitudes than do messages attributed to a highly credible source (Costanzo et al. 1986). Craig and McCann (1978) found that households receiving pamphlets on energy conservation thought to be distributed by the state regulatory agency used less electricity than did households receiving identical pamphlets believed to be distributed by the local electric utility company. Utilities are often perceived as not being trustworthy (Costanzo et al. 1986).

Even when seen as being trustworthy, water utilities can endanger their credibility by "crying wolf" and asking for unnecessary water conservation measures. For example, in 1983 the Salt River Project in Arizona was in the middle of a long-term water conservation campaign when large rains in the nearby mountainous areas called for adjustments in reservoir operations and the release of approximately 200,000 acre-feet of water to the usually dry Salt River (Mee 1985). This most likely ruined the credibility of the Salt River Project conservation program and those of local water providers who were also requiring water conservation.

Credibility problems can be overcome by strictly monitoring information sources in the community and by making available the resources and skills of the water utilities to nonprofit and neighborhood groups not involved with conflicts of interest (Stern and Aronson 1984). Any type of positive involvement in the community also has a potential of enhancing credibility.

The Message Should Be Clearly Applicable to the Person Receiving It

The information should be sufficiently specific to the person's particular situation (Planning and Management Consultants 1983). The more personal the information, the higher the likelihood that it will be perceived and processed by its receiver.

A letter from a mayor to all property owners detailing a proposed Corps of Engineers reservoir project provides an example of specific personal information. In the letter, the mayor explains why the project is desirable for both the community and for the individual. Construction of the reservoir will allow for a controlled flow of water, reducing both the risk of flooding and the areas susceptible to flooding. This type of information makes the letter recipients aware of how the project will be in their best interest. Request for project support in such a letter may be significantly more effective in achieving support for the project than a generalized advertising campaign.

The Message Must Be Clear, Specific, Concise, and Concrete

Both the theory of learning and the theory of communication indicate that clear, specific, concise, and concrete information is remembered best (Ester and Winett 1982).

Clear message. The message should be easily understood, free from obscurity and ambiguity. Every effort should be made to reduce ambiguity of the message. It must clearly articulate the purpose of the communication and the actions requested from the person receiving the information. For example, a statement such as "If you do not leave your house immediately, the floodwaters will close your last escape route," is clear, while "It is advisable for people to leave their homes because of the floodwaters," is not clear as to the impending danger confronting the residents.

Specific message. Psychological research on "prompts" designed to evoke a desired behavior shows that their effectiveness depends greatly on their specificity (Stern and Gardner 1981). Messages like "Turn off the water while brushing your teeth" are likely to be more effective than exhortations like "Conserve water!" or some vague prompts like "Don't be a drip!" or "Be water wise!"

Concise message. Messages have to be brief and free from all unnecessary elaborations and superfluous detail. Reading a wordy brochure or newspaper advertisement may easily become too tiresome a task.

Concrete message. Borgida and Nisbett (1977) tested impacts of abstract and concrete information among undergraduate students and found out that most people regard so-called base year data (i.e., statistical summaries of population) as if they were uninformative. Apparently this kind of information lacks impact because of its abstract, insipid nature.

Multiple Messages Should Contain a Common Theme

Since most public education and information campaigns use multiple means of communication (e.g., mail, billboards, newspaper inserts, radio, or TV messages), a campaign should introduce a common theme in the form of a logo or a slogan.

The purpose of such a theme line is twofold:

- It permits fragmentation of the campaign into a number of specific messages delivered at different points in time, all messages containing the same theme.

- It depicts the strategy of the entire campaign. For example, "Beat the Peak" was used as a theme line that captured the

Every effort should be made to reduce ambiguity of the message. It must clearly articulate the purpose of the communication and the actions requested from the person receiving the information.

strategy of the conservation program aimed at reducing peak water demand in Tucson, Arizona.

Guidelines for Seeking Risk Communication Feedback

As already argued in the introduction to this chapter, we recommend that a systematic effort to obtain feedback be part of every risk communication exercise. The most efficient way to do this seems to be to convene one or more focus groups composed of members of the intended audience (Stewart and Shamdasani 1990). What such a group or groups should be used to explore will vary with the objective of the communication exercise.

When Understanding Is the Objective

While the principles developed above for the content of risk communication attempt to anticipate and deal with specific problems identified in the literature, our understanding of these matters is growing steadily, but success can by no means be guaranteed. Accordingly, it is well to check on the progress (or lack of it) being made. The following is a minimal checklist.

- Check for the audience's interpretation of probabilities in the case at hand. This may involve pretesting physical analogy models, such as the wheel of fortune, for definitional fitness. Another question is whether the notion of independence is getting across or requires reinforcement. A third general problem area to be explored is the possibility that the audience contains a significant number of people who subscribe to some sort of causal or ethical theory of the events in question that interferes with their ability to think of them as random.

- Check for the presence of patterns of utility weights that would point toward incautious policy prescriptions. Perhaps the largest concern here is the possibility of risk seeking when losses are at stake.

- Check for the possibility of internal confusion such as that evidenced by the preference reversal phenomenon. This will probably involve asking preference questions two ways: one using strictly preference terminology; the other using the willingness-to-pay format developed in the contingent valuation literature (Mitchell and Carson 1989).

When Action Is the Objective

In this area we have somewhat more experience, primarily because the effects of weather-related hazards are often mitigated through voluntary action by citizens, and the volunteer campaigns have been studied and refined over the years. Examples of events that are conducive to the voluntary actions of citizens include shoring up a levee with sandbags to prevent flooding and a door-to-door campaign to warn people of approaching or impending danger such as a flood, brush fire, or hurricane. Nonetheless, it is still wise to seek feedback on the key issues. The following four items are particularly crucial:

- Check to make sure that the actions being touted in the campaign are perceived as effective in mitigating the threat.

- Check that the audience sees the goal of the campaign and the manner of its application and enforcement as fair and effective. (e.g., is one group, neighborhood, or town seen as carrying the load for others because of some extraneous factor that makes them/it easy to take on or easy to monitor.)

- Check that the seriousness of the threat has not been so emphasized that significant amounts of regressive behavior have begun to show up.

Summary

Social-behavioral research reviewed here provides a number of guiding principles for designing a risk communication program that addresses a given risk issue. Further illustrative examples can be found in the supplement at the conclusion of this chapter.

The guiding principles, which pertain to the content of the risk information program, can be summarized as follows.

When Understanding Is the Objective

- Uncertainty should be expressed in a variety of ways using such physical analogies as wheels of fortune and jars containing colored balls. Care should be taken to avoid encouraging thinking of independent events as cyclic, with fixed return intervals.

- Disagreements among experts should be made explicit and not concealed. If possible, the range of opinions should have probability weights attached to the alternative possibilities.

- The decision problem outcomes should be framed in at least two ways, one stated as losses from best case and one as gains from worst case.

- Stress the analogy of the project to an insurance policy against catastrophic loss whenever this is appropriate.

- Provide information that allows the audience to assess the risk (at least in terms of threats to life and limb) of the contemplated project relative to other activities and programs, both individual and collective.

When the Objective Is Action

- The campaign should effectively convey a message about the seriousness of the risk. This effort should not, however, be allowed to degenerate into a scare campaign, for the behavior triggered by fear is likely to be counterproductive.

- The program should provide social reinforcement of risk reduction behavior especially at the local level. This will cultivate strong group interest and moral commitments within the community.

- The campaign should make an attempt to convince the consumers that their actions aimed at reducing risk will help to mitigate risk impacts.

- Risk reduction efforts requested by the campaign should be equitable. All members of the community should be required to make sincere efforts to reduce the risk.

- The specific strategies of the campaign should rely, to the extent possible, on providing a feedback on risk reduction efforts and providing economic and social incentives for doing so.

Design and Delivery

Additional guiding principles pertain to the message design and delivery. These are:

- Messages should be vivid, that is, evoking lifelike images within the mind.
- Messages should come from a credible source. Information from authoritative

sources is more likely to be believed and, therefore, acted upon.

- The message should be clear, specific, concise, and concrete. Words used in a message should immediately bring an image to a person's mind. Specific but concise messages are easier to read and understand.

- The message should be clearly applicable to the person receiving it. This requires that information should be "personalized" or "localized."

- The means for delivering the message should make the maximum use of person-to-person communication through local media personalities, leaders, and citizen advisory groups. Impersonal messages should be avoided.

- Modeling of risk reduction behavior by respected individuals in the community should be sought as the most powerful means of persuasion.

Supplement of Examples to Chapter VI

Supplement

This supplement presents additional examples that illustrate some aspects of the basic principles of risk communication discussed in Chapter VI. The main themes addressed in Chapter VI are shown in Table S-1.

These examples were extracted from case studies and related materials that characterize Corps missions and are intended to provide further insights for planners on how risk can be communicated at various stages in the planning process.

Table S-1

Communication Themes and Examples

Theme	Example
Effectiveness of risk communication measures	Example 1, 6, 7
Content of the message	Example 2
Misconception of the notion of probability	Example 3
World-view related problems	Example 4
Feed-back from the audience	Example 2, 5

Example 1

A Corps planner should seriously consider public risk communication as an important part of actions contributing to flood protection. An illustration can be made from a study performed by Baumann et al. (1989) evaluating a public information campaign encouraging floodplain residents in Illinois to take protective measures against floods. This study showed that information can be an effective component in the reduction of potential flood damage, if the basic principles of communication form are obeyed. Moreover, the authors show that for a program to be effective, it need not be expensive nor elaborate. It was shown that the least-intensive, least-costly program was as effective in bringing about change as the more intensive and more costly programs. This is not to conclude that any type of minimal information program will be effective in producing the desired changes in resident adoption of flood damage mitigation measures. The authors attribute the source of the positive results to successful risk-information conveyance (the design of the brochures). Thus, citing the authors:

1. The brochure was written to be understood by laymen; no professional or technical jargon was used.

2. The brochure was geographically personalized through the use of a photograph of a well-known landmark in the community on the cover of the brochure.

3. ... a letter accompanied the brochure signed by the mayor and by relevant representatives of social, civic, and business organizations ....

4. The brochure included information concerning the economic costs and benefits of each flood damage mitigation measure ...

Table S-2 "juxtaposes two figures—the total cost of the information programs for each site and, again for each site, the per person average increase from pre- to post-program intervention in knowledge of flood mitigation measures, positive attitude toward such measures, and actual practice of them."

TABLE S-2

Cost-Effectiveness of the Programs

	Program Cost ($)	Average per Person Pre- to Post-Program Increase In: Knowledge	Attitudes	Behavior
Rockford	1,530	.612	1.851	.699
Wheaton	730	.610	1.724	.549
Oak Lawn	570	.618	1.763	.518
Libertyville	0	.491	1.622	.259

Source: Baumann et al. 1989

"A comparison of the estimated costs with the per person net changes supports the conclusion that the program administered in Oak Lawn, the least-intensive program, is the most cost-effective program. The total costs of the Rockford program are nearly three-times greater than in Oak Lawn, yet there were no statistically significant differences in the net changes per resident."

Example 2

A Corps planner, when preparing to convey risk information concerning water deficit or potential flood, should keep in mind that certain group behavioral patterns preventing flood or deficit-related damages may already be existent among the local people. Risk recognition is not an alien factor which may be brought into the conscience of a social group by experts only. On the contrary, it is often incorporated into an algorithm of decision making which results as a form of adjustment of the group to certain conditions. Thus the planner should be prepared to address these issues in his message (whether positively or negatively).

An example of such an adaptive pattern may be found in the study of Moran (1979) who describes a decision tree that formalizes a rancher's process of decision making under conditions of drought. The tree represents relevant events and the expected consequences of each course of action (see Figure S-1). He concludes that "conditions such as extreme cold, low biological productivity, and water scarcity demand some form of adjustment by organisms occupying areas that are so constrained. In their process of adjustment, populations must face the conflict arising from having to choose optimal solutions while

maintaining the flexibility necessary to cope with the future conditions" (p. 103).

Example 3

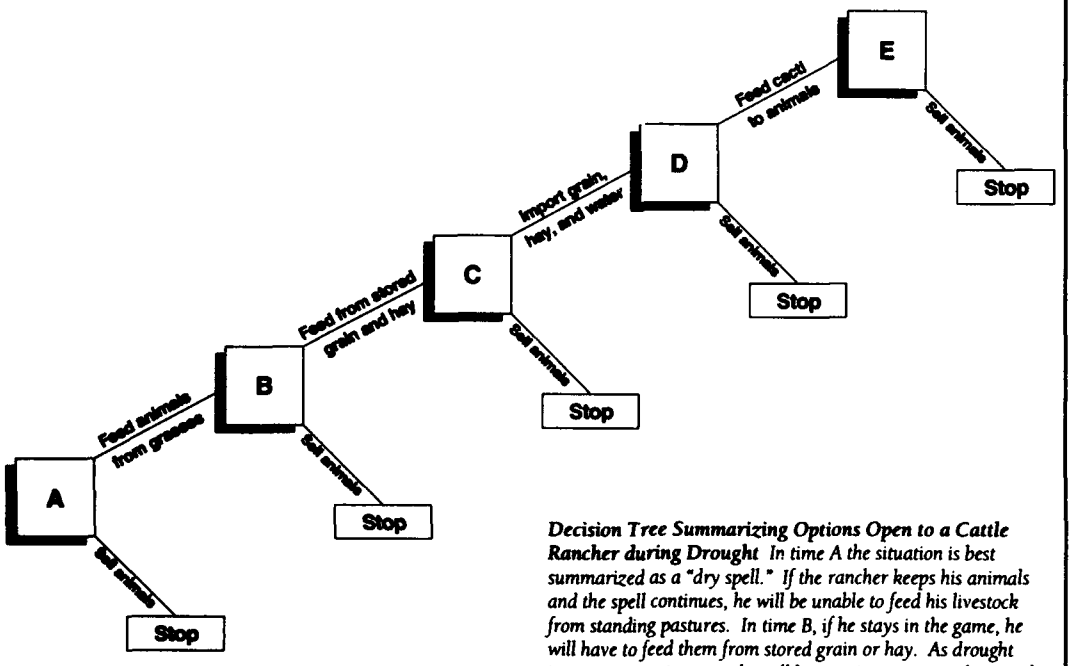
One of the problems a Corps planner may encounter when implementing a risk information campaign is a popular misconception concerning the meaning of the notion of probability.

It is tempting to put the message that "the yearly probability of flood in a certain region is 1/50" into the form "floods happen here on average once in fifty years." This should be formulated with care, for people tend to interpret that a flood "has to happen every fifty years." Some may even conclude that a flood "will come next year, for it is already forty-nine years since the last big flood!"

This is an obvious misunderstanding of the random character of weather and climate processes. The planner's responsibility is to avoid such misunderstanding, either through a careful wording ("once every fifty years" would be, in the example above, a disastrous formulation) or by additional explication revealing the metaphorical character of such formulations. It is better to express the

FIGURE S-1

CATTLE RANCHER DECISION TREE



Decision Tree Summarizing Options Open to a Cattle Rancher during Drought *In time A the situation is best summarized as a "dry spell." If the rancher keeps his animals and the spell continues, he will be unable to feed his livestock from standing pastures. In time B, if he stays in the game, he will have to feed them from stored grain or hay. As drought increases in seriousness, he will have to import grain, hay, and water to keep his animals alive (time C) and will resort to feeding them cacti, after burning off the spines, as a last resort (time D). Usually ranchers get out of the game by selling all or part of their herd before reaching points C or D. The decisions made reflect perception of drought, frequency of drought episodes in the habitat, and opportunity costs.*

Source: Moran 1979, p. 100.

probability of such an occurrence by stating that the frequency of the event is most likely to occur once in fifty years, but it does not have to.

There is a natural human tendency to seek regularity in random or even chaotic patterns, to impose order on the results of random processes. Feller (1968) offers one example in risk monitoring: Londoners during the Blitz devoted considerable effort to interpreting the pattern of German bombing, developing elaborate theories of where the German's were aiming (and when to take cover). However, a careful statistical analysis revealed that the frequency of bomb-hits was randomly distributed.

Gilovich et al. (1985) found that basketball players have no more shooting streaks than one might expect from a random process generated by their overall shooting percentage. This result runs strongly counter to the conventional wisdom that players periodically have a "hot hand," attributable to specific causes like a half-time talk or dedication to an injured teammate. One of the few basketball experts to accept this result claimed that he could not act on it anyway. Fans would not forgive him if, in the closing minutes of a game, he directed an inbound pass to a higher percentage shooter, rather than to a player with an apparent "hot hand" (even knowing that opposing players would cluster on that player, expecting the pass).

Example 4

Another problem which a Corps planner may encounter concerns a fatalistic world-view ("que sera, sera" - see Chapter VI for details on 'internal versus external locus of control'). Interestingly, the degree of fatalistic (or deterministic) attitude of a population may, geographically, vary considerably. An account of the influence of the world-view on human behavior in response to a hazard is summarized by Sims (1989):

"There is a puzzling hazard phenomenon of long standing—the death rate from tornadoes in the southern United States is significantly higher than in the Midwest. A number of investigations have attempted to account for this." ...

"In this particular case, what was brought in was a single psychological variable named "internal-external locus of control." In nonjargon terms, the issue is the extent to which one believes or does not believe that what one does largely determines what will happen to one, that one's own actions, over which one exercises control, determine the future. So-called internals see themselves as relatively self-directed, whereas so-called externals see themselves as moved by external forces such as fate, luck, or God." "Investigators found ... [that] the midwesterners were more internal, placing their faith in themselves and what they did notably to determine their lives (Baumann and Sims 1972). ... In contrast, southerners were more external, seeing themselves as borne along the currents of destiny and fortune."

"... for midwesterners, a tornado warning mobilized them; they located other family members, they battened down the hatches, they sought shelter, they listened attentively to their radios or TVs for up-to-the-minute information on sightings and direction. Again, in contrast, southerners waited and

prayed. Theirs was a patient forbearance, a fatalistic faith. If the tornado strikes, it strikes, there is nothing to be done to deflect its path, and further, there is little to be done to mitigate its effects."

Example 5

A danger to a successful risk communication campaign may result from a planner's fallacious assumption that risk communication has a uni-directional character: from experts to public. The public's intelligence should not be underestimated.

Planner must be sensitive to the response of his audience, especially at the beginning of his campaign, not only in order to match the level of risk recognition already existent in the conscience of the public, but even occasionally to learn some new elements of risk situation. By ignoring feed-back from his audience, the planner may make his message highly unconvincing. There are examples of situations in which information, well-known to the public, escapes the experts' attention. For instance Fischhoff (1989) recalls:

"To take three examples: (1) the MacKenzie Valley (or Berger) inquiry discovered that natives of the far North knew things about the risks created by ice-pack movement and sea-bed scouring that were unknown to the pipeline's planners (Gamble 1979); (2) post-accident analyses often reveal that the operators of machines were aware of problems that the designers of those machines had missed (Sheridan 1980) and (3) scientists may shy away from studying behavioral or psychological effects (e.g., dizziness, tension) that are hard to measure, and yet still are quite apparent to the individuals who suffer from them. In such cases, lay perceptions of risk should influence the experts' estimates."

Example 6

An application of the theory of persuasive communication in designing maximally effective messages for fostering water conservation behavior is described by Dziegielewski (1992). What is illustrated by this example is that a media campaign based on principles of successful risk communication may have a significant measurable impact on water conservation by a population facing a risk of drought.

Tables S-3 and S-4 illustrate principles of persuasive communication as used in television commercials. Table S-5 summarizes the effects of the campaign. The tables and the following excerpts come from Dziegielewski (1992).

"In response to the recent drought affecting most of California, the Metropolitan Water District (MWD) and some of its member agencies implemented a multimedia water conservation campaign. The campaign was designed to inform the public about the drought and the potential water supply problems and to encourage specific water conservation behavior. The media campaign, which included television, radio, print media, direct mail and bill inserts, was conducted from the middle of June 1988 through September 1988. The cost of MWD's paid advertising was $1.3 million. The content of the campaign messages was developed based on the previously discussed results of research on socio-psychological aspects of human behavior and persuasive communication, and on prior experience in designing drought

Table S-3

Application of Principles of Persuasive Communication
Television Commercial A

Drought Campaign Messages (Transcript)*	Message Analysis: Elements of Persuasive Communication
Announcer: The drought is real.(a)	Clear and unambiguous statement intended to create the awareness of drought.
Weathercaster: And we need to save all the water we can.	Information about what needs to be done. Pronoun "we" used to secure a perception of social support for the solution to the problem.
If you've got an automatic washing machine it can use 50 gallons to wash just one load.(b)	This personalized message moves from an abstract problem to a concrete, everyday situation.
So before you run it make sure it's full.	The desirable behavior is suggested using very clear and direct information on what to do.
The same goes for your automatic dishwasher.	The message is reinforced in a new context. The continued use of the pronoun "you" directs the message specifically to the viewer.
If everyone cuts back just one load of clothes and dishes a week, we could save millions of gallons of water this summer.	Links the specific action to concrete benefits of a concerted effort. Reinforces social commitment and the viewer's perception of efficacy.
Announcer: LA's top TV weathercasters remind you.(c)	Emphasizes person-to-person communication and a credible source of information.
The drought is real. And we need to save water. (a)	The main theme (seriousness of drought) is repeated. The desirable behavior is reiterated.
Now.	Simple and clear message to convey the feeling of the urgency and immediacy of the action.

Visual elements of persuasive communication:
(a) A still picture of a drying reservoir with parched sediment is shown.
(b) The announcer is demonstrating the recommended action (i.e., modeling the desired behavior) while standing beside a washing machine.
(c) A live group shot of ten well-known weathercasters is shown.
*Transcribed here video tapes were provided by the Metropolitan Water District Department of Public Affairs.

TABLE S-4

Application of Principles of Persuasive Communication
Television Commercial B

Drought Campaign Messages (Transcript)	Message Analysis: *Elements of Persuasive Communication
Screen: How to save 11,743,410,000 gallons of water.	A specific question that directs attention to how to solve the problem. A prior awareness of the drought is assumed.
Announcer: Your lawn can go an extra day without water.	A personalized message about an opportunity to conserve. Implies a minimum cost (no sacrifice) involved.
To find out, step on the grass. If it springs back up, it doesn't need water.(a)	A clear, concise and simple instruction. Supports the claim of "no sacrifice." Encourages new behavior through positive action while acknowledging values important to the viewer (e.g., proper lawn maintenance).
Think about it. If every lawn in front of every house in every town in all of Southern California goes one extra day without water every week, we would save billions of gallons of water this summer.(b)	The action's efficacy is explained. A clear link is shown between one less lawn watering and the billion gallon savings. Pronoun "we" used to strengthen the social commitment.
Easy.	The simplicity of the statement corresponds to the content of the message (i.e., simplicity of the desirable behavior modification).
And during the drought, that's something the Metropolitan Water District wants everyone to know.	Identifies the context (drought) for the new desirable behavior and the credibility of the source.

Visual elements of persuasive communication:
(a) A homeowner (resident) models the behavior by stepping on the grass in his front lawn while picking up the morning paper.
(b) An ascending aerial shot moving from the house's front yard to a street and finally to the larger urban area accompanies the narrative. The camera stops at a receding water line.
(c) The receding water line in a reservoir provides a depiction of drought. The logo of MWD shown across the screen.

*Transcribed here video tapes with commercials were provided by the Metropolitan Water District Department of Public Affairs.

Table S-5

Measurement of the Effects of the Drought

Self-Reported Behaviors and Attitudes	Percent of Responses Before	After	Change[a]
A. Conservation Behaviors:			
(1) Reported taking action to conserve water	65	72	+7
(2)Watered lawn and shrubs less often	25	30	+5
(3) Took shorter showers	15	19	+4
(4) Installed low-flow showerhead	14	20	+6
(5) Installed water savers in toilets	12	16	+4
(6) Used dishwasher (washing machine) less often	8	16	+8
(7) Repaired drips or leaks in faucets or toilets	8	11	+3
(8) Washed the car less often	6	10	+4
(9) Used broom rather than hose to clean driveway	5	9	+4
(10) Turned off water while brushing teeth or shaving	3	8	+5
(11) Watered lawn and shrubs at night	3	6	+3
(12) Reported number of conservation measures:[b]			
None	38	26	-12
One measure	20	19	-1
Two measures	25	27	+2
Three or more measures	17	28	+11
B. Pro-Conservation Attitudes:			
(1) Believed that there was a drought	50	58	+8
(2)Believed there was a need to conserve	95	96	+1*
(3) Believed in success of a concerted effort	59	60	+1*
(4) Disagreed that farmers waste water	80	85	+5
(5) Agreed that they use more water than needed	30	21	-9
(6) Disagreed that agencies exaggerate the need	69	76	+7
(7) Disagreed that business and industry conserve	61	67	+6
C. Reported Efficacy of Conservation:			
Perceived change in household's water use:[c]			
So small you can't see it	26	20	-6
5 percent or less	13	14	+1
5 to 10 percent	24	25	+1
10 to 20 percent	19	20	+1
20 to 30 percent	10	12	+2
30 percent or more	8	9	+1

Source: Derived from Opitz and Dziegielewski (1989).

a. All changes are significant at the 0.05 probability level of the chi-square statistic (except where indicated by the asterisk).

b. distribution of answers in the two samples is statistically different.

c. Distribution of answers in the two samples is not statistically different.

response programs. Tables S-3 and S-4 provide two examples of the application of principles of persuasive communication to the content and form of campaign messages."

"Table S-5 compares the self-reported conservation behaviors, attitudes and perceptions of survey respondents before and after the media campaign. The results indicate that the campaign messages had a significant impact on the customers' water conservation behavior. About 72 percent of respondents reported taking some action to conserve water. This represented a 7 percent increase when compared to the pre-campaign survey. The frequency of reported conservation actions showed a significant increase for ten measures, seven of which were recommended in campaign messages. Additionally, there was a significant increase in the total number of actions reported."

"Most respondents believed in the efficacy of conservation in alleviating the effects of drought. About 60 percent believed that they saved 5 percent or more water as a result of their conservation efforts. However, both surveys revealed the apparent lack of respondent knowledge about the number of gallons their household uses each day. About 21 percent were unable to risk a guess. Among those who did only 9 percent were more or less correct prior to the campaign and 13 percent after the campaign. This slight increase was attributed to the information ... that was included in the campaign messages."

"The overall conclusion of this survey research is that the public information campaign had a significant impact on the residential water users' knowledge, attitudes and behavior relevant to achieving water conservation. This is demonstrated by statistically significant increases of 5 to 10 percent in pro-conservation attitudes and conservation behaviors before and after the campaign. Using an econometric model of total water demand in Southern California, the actual water savings were estimated at 90,000 acre feet (111 hm^3) [Chesnut and McSpadden, 1989]. Assuming that all savings came from the residential sector, they represent a 4 percent reduction of the expected residential water use in 1988."

Example 7

One observed phenomenon relevant to risk communication is the general tendency for people to ignore the risks of low probability, and this attitude does not depend on a particular type of hazard, be it flood, landslides, tornado, tsunami, volcano or earthquake.

Some relevant conclusions were drawn on the basis of results of an intensified risk communication campaign that was undertaken in conjunction with the Parkfield earthquake prediction as reviewed by Mileti et al. (1992). Here are a few excerpts from this document which summarize the implications.

"On November 16, 1984, two U.S. Geological Survey (USGS) Scientists - William H. Bakun and Allan G. Lindh - submitted to the National Earthquake Prediction Council data indicating that the chances of an earthquake were very high for the region around the tiny town of Parkfield in central California.... Within three months, both the national council and the California Earthquake Prediction Evaluation Council had endorsed the scientists' prediction. Thus, the Parkfield Earthquake Prediction Experiment became

the first scientifically credible, long-term earthquake prediction approved by both the National and California Earthquake Prediction Evaluation Councils. The Director of USGS issued a formal public forecast of the quake in April 1985. The forecast stated that there was a 90-percent probability of an earthquake with a Richter-scale magnitude of 5.5 to 6.0 occurring sometime between 1985 and 1993 in the Parkfield area.... The release of this forecast became a national media event, and residents of the area have received streams of information about the prediction. To date, however, no new or revised predictions have been issued for the next Parkfield quake, nor has the earthquake occurred.... To determine if, how, and why the imperiled population attempted to mitigate and prepare for the forecast earthquake, the authors of this article selected three communities to study within the Parkfield area. Another goal was to advance the theory of risk communication by determining what would convince people to take action."

The findings of this research documented again that "public belief in disaster risk requires a stream of comprehensive, repetitive risk information from diverse sources," and that, "the most believable sources are a mix of scientists and public officials." But more specific conclusions were obtained:

"Although previous research has indicated that electronic media are more effective than the print media for short-term risk warnings, the responses to this survey showed that printed matter delivered directly to homes is the most effective vehicle for informing households about long-term risks.... Most of the people's preparations were the very things that the brochure and other communications recommended. But people did not take these actions simply because they were publicly recommended. In fact, the survey showed that the prediction and subsequent information flow had no direct impact on the public's behavior to get ready. Instead, what people did to mitigate and prepare for the quake was the direct result of what people thought were their own ideas. In all three [surveyed] communities, personal ideas about what to do were formed while individuals interacted with other people, sought and discovered new information about what to do on their own, and observed others' preparations.... The most o' vious lesson from this experience is that one must disseminate a written brochure to the public. A written document gives people something to refer to as they become interested in the topic. If funds exist, mail the brochure to people's homes.... The distribution of a brochure is not enough, however, and it must be supplemented.... People need multiple information sources to reinforce the risk information in the brochure. People seeing neighbors, friends, and relatives preparing for the hazard is also useful reinforcement."

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